



2003 GEORGIA BASIN/PUGET SOUND

Research Conference

Applying
Science and
Information to
Sustainability
in a Shared
Transboundary
Ecosystem

Abstracts & Biographies

March 31 – April 3, 2003

Westin Bayshore
Vancouver,
British Columbia

Conference hosted by:



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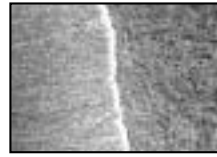
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**Westin Bayshore
Vancouver,
British Columbia**

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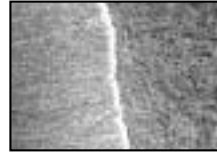
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**Abstracts
of
Oral
Presentations**

Session 1A: PEOPLE AND PROCESSES— COLLABORATIVE MANAGEMENT (I)

The Importance of Human Intervention in the Evolution of Puget Sound Ecosystems

Russel L. Barsh

*Center for the Study of Coast Salish Environments
(Samish Indian Nation)*

Contemporary restoration efforts in Georgia Basin-Puget Sound tend to rely upon baseline data that are no more than 100 years old. Our research indicates that the marine ecosystems observed by European explorers and settlers in the 19th Century were already profoundly shaped by systematic human interventions and cannot be restored without an understanding and renewal of the human practices that created and sustained them. As a first step, we compiled existing archaeological and ethnographic data on marine resources use for 408 locations in the San Juan archipelago and identified six plausible hypotheses that we plan to test using biochemical and genetic studies of faunal remains at 20% of these sites. Our hypotheses focus on the following:

- (1) The role of fire in expanding coastal wetlands.
- (2) The effect of hunting pinnipeds and small cetaceans on maintaining salmon stocks.
- (3) Heavy but localized seasonal human harvesting of sea urchins and the distribution of kelp forest.
- (4) Dense patches of forage for salmon at those weirs and reef-nets where salmon were processed in large numbers.
- (5) Selective harvesting and salmonid genetic diversity.
- (6) Harvesting techniques and the structure of oyster reef communities.

Our hypotheses were critically informed by discussions with knowledgeable elders.

Collaborative Governance for River Basin Management

Jack Blaney

Fraser Basin Council

Governance can be defined as the methods by which power is exercised, how citizens are given a voice, and how decisions are made on issues of public concern. In hierarchical governance systems, decisions are made in a “top-down” fashion, often with incomplete information and with little or no consideration for the needs of all parties affected. Collaborative governance represents an innovative way of making decisions that overcomes jurisdictional constraints and breaks down the barriers between otherwise isolated decision making processes.

Since 1997, a non-profit organization, the Fraser Basin Council, has employed a unique model of collaborative

governance for cooperative management of a major river basin. The Fraser Basin Council model is inherently transparent, inclusive and accessible, and brings all the sectors of society together in a respectful environment as a diverse group of equal partners. It also acknowledges First Nations as a 4th order of government, actively promotes integrated consideration of social, economic and environmental dimensions in decision-making, and the use of the best available information to guide decisions.

This paper presents the Fraser Basin Council’s collaborative governance model and the lessons learned by the Council in using this model to address complex real-world sustainability challenges in the Fraser Basin such as integrated flood hazard management, strengthening communities and sustainable fisheries.

Resolving Environmental Disputes Through Collaborative Planning: A Case Study of Land Use Planning in British Columbia

Tanis M. Frame, T. I. Gunton and J.C. Day

Simon Fraser University

A major challenge to sustainable management is resolving disputes among competing stakeholders over the use of natural resources. Recent literature proposes the use of innovative shared decision-making (SDM), or collaborative planning models, to resolve planning disputes.

The objective of this research is to assess the effectiveness of the SDM approach used to develop 17 land use plans covering 85 percent of the land base in British Columbia. The evaluation is based on the results of a survey conducted of 260 participants from 17 SDM processes to assess the degree to which the process met 25 evaluative criteria, and to assess the strengths and weaknesses of the processes.

Almost all 17 SDM processes achieved consensus agreements despite a previous history of intense conflict among competing stakeholders. Additional benefits included improved relationships, increased understanding, networks among diverse stakeholders, significant learning, and sharing of information. Participants also developed skills and an understanding of collaborative tools for future decision making.

The case study also identifies the limitations of SDM and the keys to successful SDM management including factors related to process design and external circumstances. If these factors are addressed, SDM are a feasible and valuable tool in resolving conflict and preparing plans.

Byrne Creek Watershed Education and Business Inspection Program

Yota Hatziantoniou

City of Burnaby, Environmental Services Division

Environment Canada and the City of Burnaby have jointly launched an education and business inspection program to reduce discharges of chemicals from industrial and

commercial establishments into storm sewers that lead to Byrne Creek, in Burnaby, BC. The inspection component of the program has also been assisted by staff from the Ministry of Water, Land and Air Protection.

To-date, business inspections and accompanying cross-connection dye-tests have been completed for the upper watershed area, and educational materials have been developed and distributed. Progress is also being made on the development of business-specific Best Management Practices (BMP) guides, and the sampling of stormwater for the identification of upstream contaminant sources. The complete findings of this program, including a description of lessons learned and future recommendations, will be summarized in a final report in early 2003.

This program was funded in part by the Georgia Basin Ecosystem Initiative (GBEI) - a partnership that provides tools, support and a framework for action towards sustainability in the Georgia Basin.

The Canada-US Gulf of Maine Program: Bureaucrats Without Borders

Larry Hildebrand

Environment Canada

The Gulf of Maine is a semi-enclosed marine ecosystem that is encompassed by the northern New England states and two Canadian Maritime provinces. In 1989, the Governors of Maine, New Hampshire and Massachusetts and the Premiers of Nova Scotia and New Brunswick, recognized the need to work collaboratively and across provincial, state, international, terrestrial and maritime borders, to manage this shared resource on an ecosystem basis. The Gulf of Maine Council on the Marine Environment was thus established to facilitate the sharing of information, establish a common vision and set of goals and objectives, and to develop and implement a common action plan that would maintain and enhance environmental quality and to allow for sustainable resource use by existing and future generations.

For the past 13 years, state, provincial and federal agencies from the region have been working creatively and collaboratively on issues of common interest and concern to this shared ecosystem. This international program is somewhat unique in that it was established, and is led by the provincial and state governments; the federal governments are invited partners who participate and provide support, but do not dictate the agenda nor lead the process of collaboration. The Gulf of Maine program offers important lessons for cooperative ecosystem management.

An Economic Approach to Environmental Sustainability

Linda Lyshall

Evans School of Public Affairs at the University of Washington

There is a history of antagonism between industrial interests

and environmental protection efforts. Core business values have often excluded environmental responsibility, and environmental regulations have often discouraged industrial progress. Many companies, however, are turning this around and creating a new phase of industrial processes that are compatible with natural processes. By designing industrial and manufacturing systems for environmental sustainability businesses have realized fewer expenses and liabilities with greater revenue. Through elimination of waste, companies are saving money by increasing material use efficiency and decreasing waste disposal costs. Utilizing recycled or renewable materials indicates lower material costs and less extraction of raw materials, leading to fewer dollars spent on remediation. Employing less toxic materials can provide the same performance with less cost and less risk. This new terrain in systems design offers opportunities for businesses to achieve a competitive advantage and exceed environmental regulations while practicing environmentally sustainable methods.

Session 1B: CLIMATE CHANGE (I)

Postglacial Climate and Environmental Change in Southwest British Columbia, Canada

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Ian R. Walker

Biology Department, Okanagan University College

Climate in southwest British Columbia has varied dramatically since the last glaciation. These climatic regimes have caused major changes in the structure of both terrestrial and aquatic ecosystems. Paleoecological investigations using pollen, chironomid, plant macrofossil, and charcoal analyses have revealed that the rate and severity of climate change is highly variable. The most prominent climatic shifts in the region are deglaciation (wasting of the ice sheets until ~12,000 to 10,000 BP), Younger Dryas (a rapid 50-100 year cooling period ~ 10,500 BP), early-Holocene Xerothermic a warm, dry climate period between 9500 and 7000 BP where fire adapted Douglas-fir and Garry oak ecosystems prevailed), Neoglaciation (the later half of the Holocene where modern coniferous forests developed), Little Ice Age (a cooling period in the 1800s where several glaciers in the Cordilleran region expanded and temperatures were cool around the world), and modern climate conditions. Global climate change is expected to impact ecosystems of southwest B.C., when exacerbated by anthropogenic actions future ecosystem structure may be quite different than today. Paleoecological studies allow scientists and decision makers to examine past ecosystems and see how they have responded to past climate change in order to prepare for future climate related impacts.

Are Peak Snowpacks in the Skagit Basin Decreasing Over Time?

Scott Pattee and Jon Lea

USDA NRCS

The measurements of the snowpack in the Upper Skagit River Basin have been ongoing since the early 1940s. Analysis of long-term snow course records at selected stations at various elevations in the Skagit River basin were analyzed to determine if there are any changes in the timing or in the peak accumulation of Snow Water equivalent (SWE). If changes were noted are they significant. Early indications are that there has been a decline in the peak accumulation. In recent years some of those stations that had the long period of observed snowpack records have had SNOTEL stations installed. The data from these SNOTEL sites were reviewed to see if any of the long-term trends might have been noted in the shorter record. The SWE from the long-term snow courses and the SNOTEL sites were compared PDOC and SOI indices and correlation's developed.

Long-term Trends In Snowpack in the Northwest, and Their Climatic Causes

Philip W. Mote

Climate Impacts Group, University of Washington

Alan F. Hamlet and Dennis P. Lettenmaier

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University of Washington*

A long-term warming trend in much of the west has been linked to an earlier spring freshet in many basins. Trends in snowmelt are a complex mixture of natural climate variability (temperature and precipitation) and long-term regional warming trends. We hypothesize that statistically significant trends in snowpack in areas with winter temperatures close to freezing may already be discernable given the small amount of warming that has been observed over the 20th century. These changes may provide early warning of climate change impacts and opportunities for long-term climate monitoring. Consistent long-term observations of snow pack (snow water equivalent) over large spatial areas are rare, but we augment these data using the Variable Infiltration Capacity (VIC) hydrologic model, which simulates snow pack at 1/8th degree resolution over the Northwest. Snowpack simulated for the 20th century shows clear evidence of warming-induced declines, augmenting streamflow observations and underscoring that "global warming" is not merely a distant possibility but is already happening.

Long-term Changes In Rainfall Intensities on the Greater Vancouver Regional District and its Implications for Stormwater Management

Matthias Jakob

Kerr Wood Leidal Associates L td.

Ian McKendry

*Department of Geography,
University of British Columbia*

Rick Lee

Canadian Institute for Climate Studies

Ed von Euw and Robert Hicks

Greater Vancouver Regional District

This study investigates changes in rainfall intensity and frequency of high intensity rainfall in the Greater Vancouver Regional District (GVRD). Data on precipitation intensity for 9 GVRD stations and 3 MSC stations are gathered from 5 minutes to 24 hours duration. Analysis of GVRD data indicated only one station with a statistically significant upward trend for the 5 minutes to 2 hours durations for the annual time series; however that site was found to be locally influenced and the data compromised, thus rendering the trend unlikely. A month-by-month analysis for all analysed stations demonstrates statistically significant upward trends particularly for the months of April, May and June, which are also the months of highest convective activity. Strongest trends were found for the shorter durations (up to 2 hours). High-intensity rainfall threshold exceedances were computed for all stations and durations to investigate possible long-term changes in the frequency of high intensity rainfall. This analysis demonstrates an increasing trend in threshold exceedances particularly during the 1990s. A strong increase in threshold exceedances is noticeable between the last Pacific Decadal Oscillation (PDO) cool phase that ended in 1977, and the last warm phase that ended probably in 1998. Variability of PDO and ENSO (El Niño Southern Oscillation) is significantly greater than the signal attributed to the enhanced greenhouse effect. The results of this study are consistent with the findings from recent scientific literature suggesting that there is, as yet, little evidence for an increase in high intensity precipitation over southwestern British Columbia. These results suggest that there is no urgent need to upgrade the sewerage and drainage system. However, the observed increase in frequency of high intensity rainfall events implies that there will be more frequent flood flows resulting in more channel erosion and nuisance flooding. This would have implications for managing stream health and flood management planning. Also, there is a need to review how intensity-duration-frequency (IDF) curves are developed and used since the data period of record may be significantly skewed by the effects of the PDO and ENSO phases. This would have direct implications for sizing and costing of stormwater channels and facilities. Given the correlation between PDO and ENSO cycles and high rainfall intensity occurrence, if historical patterns repeat, then lower-than-normal rainfall intensities can be expected for the next PDO cool cycle which may have begun in 1998.

Interdecadal Changes in the Hydrometeorological Regime of the Pacific Northwest and in Regional-Hemispheric Climate Regimes, and Their Linkages

J.J. Vaccaro

U.S. Geological Survey

An analysis of selected hydrometeorological (HM) data for the Pacific Northwest, regional-to-hemispheric atmospheric-circulation data, and sea-surface temperature (SST) data for the North Pacific, demonstrates that data characteristics changed between three successive interdecadal periods (pre-1947, 1947-76, and post-1976). The HM data included monthly precipitation totals for 50 sites and 29 climate divisions, and streamflow averages for 112 sites. The atmospheric data included indices, measures of geostrophic flow, and a subset of the Northern Hemisphere 700-millibar geopotential height data.

Changes in atmospheric and SST data are clearly linked to and have influenced the changes in the HM regime. These changes suggest that the HM regime in the post-1976 period was different than the previous two periods.

The 1946-47 interdecadal-regime boundary appears to have been hemispheric in nature, and is documented in Arctic ice-concentration data and two sea-level pressure indices. In contrast, the 1976-77 boundary appears to be mainly contained in the North Pacific information. This suggests the influence of the ocean-atmosphere system over the tropics and North Pacific in mediating the 1977 climate shift.

Changes in the Strait of Juan de Fuca and Puget Sound During the 2000 Drought

Jan A. Newton

Washington State Dept. of Ecology and the University of Washington

Sustained long-term monitoring of water properties are invaluable for recognizing impacts from variations in climate. It is only through increases in this understanding that effects from climate change can be assessed. Effects on local weather from anthropogenic climate change are only recently being forecast, but many models show reduced river flows in part of the year. Impacts on marine water properties and circulation in the Georgia Basin-Puget Sound region are less well known.

The recent 2000 drought gave a strong signal of reduced river flow that could be followed for its effect on water properties in the data of Washington State's Puget Sound Ambient Monitoring Program and the Joint Effort to Monitor the Strait (MEHP funding). A "densification" was apparent in the waters throughout Puget Sound, as indicated by a reduction in the density difference between the surface and bottom of the water column. This reduction in the stratification was due to more saline surface waters. Stratification regulates numerous biological and physical

processes, including the timing of the spring phytoplankton blooms, mixing, and flushing. Changes in the density gradient in the Strait of Juan de Fuca lead to a marked reduction in the geostrophic exchange velocity (linked to flushing) during the drought year as compared with the higher flow year of 2001. This difference has implications for larval and plankton dispersal/retention and water quality.

Session 1C: TREATMENT, DISPOSAL AND IMPACTS ASSOCIATED WITH CONTAMINATED WATERS

Subsurface Flow Wetland Treatment of Dairy Farm Stormwater

Ian D. Bruce

Peninsula Streams

Nonpoint source pollution from agriculture can cause chronic water quality impacts in small streams and downstream marine waters. In North Saanich, B.C., water quality sampling of TENTEN Creek in February, 2000 indicated excessive levels of nutrients, suspended solids and fecal coliforms present in stormwater originating from an adjacent dairy farm. The tributary from the farm crosses into lands managed by the Victoria Airport Authority (VAA).

The WSIKEM-TENTEN Stewardship Project, working in partnership with VAA, Pendray Farms, Tseycum First Nation and Fisheries & Oceans Canada, developed a stormwater interception and treatment complex beginning in August, 2000. A 2.1 million litre stormwater detention pond was constructed with two piped outlets, one which fed a 150 metre long, 3 metre wide sub-surface flow constructed wetland. Monitoring of treatment efficacy in the winter of 2000-01 indicated that up to 99% of source fecal coliforms were removed, while nutrient and TSS reductions ranged from 25-95%. Subsequently a second wetland was constructed in 2001 to treat additional stormwater, and we estimate that over the two years of operation, 90 million litres of stormwater have been treated. This presentation discusses the project, its successes and limitations, and the role of stewardship partnerships in habitat and water quality restoration.

GBEI Wastewater Research that Led to the British Columbia Organic Matter Recycling Regulation

Jack Bryden

British Columbia Ministry of Water, Land and Air Protection

Wastewater treatment facilities in the Georgia Basin generate more than 20,000 dry tonnes of biosolids each year. As treatment facilities are upgraded and the population within the region increases, biosolids volumes are mounting.

The BC Organic Matter Recycling Regulation (OMRR) was enacted on February 5, 2002. The regulation contains standards for the management of wastewater residuals (biosolids), resulting from the municipal wastewater treatment process, for use as a soil amendment or fertilizer. The regulation allows reuse as an alternative to incineration or landfilling. Together, the Georgia Basin Ecosystem Initiative and the BC Ministry of Water, Land and Air Protection funded four important studies that led to this initiative. These were:

- The Georgia Basin Biosolids Inventory and Mercury and Dioxins and Furans Characterization
- Reducing Contaminant Sources to Municipal Wastewater Treatment Biosolids
- Potential for Exposure to Polychlorinated Dibenzo-p-dioxins and Dibenzo-furans when Recycling Sewage Biosolids on Land.
- Best Management Practices Guidelines for Biosolids Applied to Land

OMRR requires that the process of recycling organic material adhere to performance-based standards related to the use of the material – be that as a retail fertilizer, ingredient in a soil product or soil amendment in restoration and reclamation activities. The changes in the composting and recycling regulatory framework have promoted contaminant reduction, reduced incineration and landfilling and facilitated the recycling of organic amendments. This presentation will give an overview of how these four studies contributed to this initiative and how they can be used by others.

Review and Update of the “Indicator And Trigger” Approach to Managing Discharges into Marine Receiving Environments

Brenda J. Burd

Ecostat Research Ltd.

Paul van Poppelen

Greater Vancouver Regional District

With the wide variety of management issues facing coastal jurisdictions, rational decisions have to be made about what to manage and how to manage it. Managers are faced not only with environmental responsibility, but with fiscal and societal responsibility as well. The foundation of environmental management is scientifically-based knowledge, with a reasonable temporal and spatial confidence, a long view, and the will and resources to implement it.

As part of the LWMP, GVRD has committed to a scientifically-based receiving environment monitoring program to assist in management of the two marine outfalls in the lower mainland. This work is multidirectional and includes development of sampling designs for aquatic habitats, analysis of benthic community response and recovery patterns as they relate to the environment, and statistical evaluation of observed response patterns. Fundamental to this approach is the need to rigorously

quantify the magnitude and extent of biological and chemical effects of outfalls on the receiving environment. In aid of this, an extensive literature review has been conducted to assess the value and reliability of qualitative and quantitative environmental indicators, warnings and triggers recommended or in regulatory use by other marine jurisdictions and their applicability to the Georgia Basin.

Effect of Taxonomic Resolution on Detection of Benthic Impacts of Salmon Farming in British Columbia

James E. Dalby, Jr., J. Bernie Taekema,

Eric R. McGreer and Lloyd J. Erickson

British Columbia Ministry of Water, Land, & Air Protection

Studies of the effects of human disturbances on marine benthic communities often include taxonomic analysis of invertebrates. Unfortunately, identification to the taxonomic level of species tends to be time-consuming and expensive. If detection of impacts were as likely using data at taxonomically higher levels (genus, family, order, class, phylum), then we could justify identifying the biota to these levels instead, and potentially save much time and money. Family is the ideal level for 3 Mediterranean communities impacted by aquaculture, but not necessarily for other communities (Karakassis & Hatzilyanni 2000). In 2000, we collected biological sediment samples near fish farms on the British Columbia coast. Univariate statistical analyses (ANOVA, regression) applied to taxon richness data show that impacts are detectable at taxonomic levels no higher than family or order, depending on distance from farm, farm site, and statistical test used. Results of multivariate analyses (MDS, ANOSIM) will also be presented. These early findings suggest that it would be reasonable to identify invertebrates to levels above species in future BC aquaculture studies. Researchers studying other kinds of human disturbances in the GB/PS region may be able to reduce costs and time spent obtaining invertebrate data by doing analyses of this kind.

A Quantitative Assessment of Agricultural Intensification and Associated Waste Management Challenges in the Lower Fraser Valley

H. Schreier and R. Bestbier

University of British Columbia

G. Derksen

Environment Canada

Changes in agricultural intensification in the Lower Fraser Valley were evaluated using agricultural census data for 1991, 1996 and 2001. Recent trends in animal numbers, and land use changes were determined and a nutrient balance model was used to determine areas of surplus nutrient application for both nitrogen and phosphorus. The results showed that the livestock industry remains very dynamic. Between 1996 and 2001 the overall number of hogs produced has declined by 5 %, cattle production remains

relatively stable, but chicken production increased by a massive 36%. The continuous concentration of animals in key agricultural areas is of particular concern. Based on the nutrient budget analysis it is evident that most of the areas that had large nutrient surplus applications in 1996, continued to have waste nutrient management problems. Not only have the application rates increased but the atmospheric return of nitrogen is much higher than the rates used in 1996. The interactive nutrient model was redesigned and linked to GIS to enable users to see where the nutrient surplus areas are, how the applications have changed over the past 10 years, and how the problem can be mitigated by running different scenarios. This dynamic model allows decision-makers to compare different scenarios and select various options for improving agricultural waste management under different agricultural growth projections.

Biological Effects from Nonpoint Source Pollution in an Agricultural and Urban Stream Located in the Lower Fraser River Valley

M. Sekela, S. Sylvestre, M. Fluegel, G. Moyle and T. Tuominen

Environment Canada

Oncorhynchus clarki (cutthroat trout) and *Pacifastacus leniusculus* (signal crayfish) were used as bioindicators to study the effects of agricultural and urban runoff in two streams located in the Lower Fraser River Valley, British Columbia, Canada. Three sampling sites were located in the Elk Creek watershed: a reference site located upstream of anthropogenic sources of pollution and two sites located downstream of agricultural influences. A single sampling site was located in the Yorkson Creek watershed downstream of urban influences. Streamside flow-through aquariums were used to expose hatchery-raised cutthroat trout and crayfish to stream water for approximately 60 days. Sampling was conducted in the fall of 1999, 2000 and 2001 as well as in the spring of 2000. Results indicate that when compared to the Elk Creek reference site the cutthroat trout and crayfish exposed to stream water downstream of agricultural and urban influences had elevated stress indicators including mixed function oxygenase (MFO) induction. Reduced swimming performance was also observed in the cutthroat trout at the downstream sites.

Session 1D: ENVIRONMENTAL EDUCATION

Empowering Communities Affected by Sediment Contamination with Collaborative, Science-based Risk Communication Tools

Christina H. Drew, Nancy L. Judd, William C. Griffith, Elaine M. Faustman and Timothy L. Nyerges

University of Washington

Complex sediment contamination pervades Puget Sound and the Georgia Basin. Cleaning up contaminated areas should involve affected parties, technical specialists

and decision makers in early, active and continuous dialogue. Unfortunately, deficiencies in this dialogue have led to high levels of distrust among communities, government agencies and potentially responsible parties. Complexities of understanding exposure and risk are often barriers to community participation. In addition, it is difficult for decision makers to show communities how their perspectives have affected decisions. Improving participation in risk-based dialogues is essential for empowering affected parties to be more active in the cleanup process and to ensure that decisions are sustainable. The dialogue should be both analytic and deliberative – i.e., use analytic procedures to inform decision conversations and frame analyses with outcomes from deliberation. In this paper we argue that transparency is essential for understanding how analysis informs the deliberation, and, likewise, that considering the values of affected parties is critical for understanding how deliberation frames the analyses. We also share lessons learned from previous research about developing collaborative science-based information tools to assist the dialogue about complex decisions and cleanup activities that can be applied to sediment contamination issues in Puget Sound and the Georgia Basin.

Acknowledgement:

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Puget Sound/Georgia Basin: Protecting and Managing an International Ecosystem: A Tri-University Dialogue

Nadine Fabbi, Don Alper and Ann Lesperance

University of Washington

James Tansey

University of British Columbia

The University of Washington, University of British Columbia and Western Washington University initiated a joint environmental studies program in the fall of 2001. The program was created in response to the need for both education and research that recognizes the interconnectedness of the Puget Sound/Georgia Basin bioregion. Additionally, the program was designed to respond to the increased demand for internationalization in higher education and to provide students with foreign exchange opportunities.

The program includes:

- (1) Either an undergraduate or graduate course at each of the institutions in environmental management.
- (2) An 8-part public lecture series that serves both the students in the course and members of the general public (sponsored by Weyerhaeuser).
- (3) Educational outreach to middle and high school educators.

Involving Undergraduates in Oceanographic Research: A Comprehensive Survey of Puget Sound

James E. Gawel and Cheryl L. Greengrove

University of Washington

During the summer of 2001, undergraduate students and environmental science faculty from the University of Washington, Tacoma, conducted a comprehensive oceanographic survey of Puget Sound—including the Strait of Juan de Fuca, Whidbey Basin, Main Basin, and South Basin—as part of a weeklong marine research course. Students collected hydrographic data at 30 sampling stations throughout the Sound, measuring temperature, salinity, oxygen, chlorophyll, and nutrients. A goal of our experiential learning model at UWT is to enhance undergraduate education by involving students in ongoing relevant research projects that extend beyond the classroom into the broader scientific community. To do this it is imperative to minimize costs while providing student access and ensuring data quality so that this data may be used for scientific purposes. For example, automated nutrient analysis—the standard oceanographic method—is normally cost prohibitive for use in undergraduate courses. Therefore, if nutrient determinations are to be included in undergraduate research, alternative methods that are both simple and economical are required. Nutrient samples from this cruise were measured using two methods: samples for automated nutrient analysis were processed onshore after the cruise, while duplicate samples were analyzed onboard using relatively inexpensive commercial chemical kits. We present results comparing these two methods and assess the feasibility of using inexpensive nutrient monitoring methods for use in education and volunteer monitoring programs. Nutrient data as well as other physical and chemical property distributions from this cruise are compared to historical data to show the efficacy of using data collected with limited resources by undergraduate students for larger research projects.

Reed Point Marina's Education Centre

Rod MacVicar

Reed Point Marine Education Centre

No person's knowledge can go beyond their experience. On that same idea, no person cares for that which they are unaware of. The very root and spring of the conservation and stewardship ethic lies in experience. Dave Harris, the owner of Reed Point Marina, the largest full service marina in British Columbia has taken the initiative to provide these direct experiences and communicate science and marine awareness. This centre and its programs are to serve the marina clients, school students and even graduate students in a new floating classroom, laboratory and 40-passenger research vessel.

This presentation will describe the new Reed Point Marine Education Centre and the type of programs it offers. It will explain how participants at the Centre can experience everything from tide pool life to fresh, living microscopic plankton. This is a presentation by business and industry

teaming up with stewardship science and training. The PowerPoint presentation provides an overview of the variety of people visiting the centre along with the programs they are involved in. Come and see what is going on in the eastern portion of Vancouver Harbour, Port Moody and Indian Arm to promote ecosystem health in the Georgia Basin.

Marine Environmental Education in the San Juan Islands, Washington

Chih-Fan Tsao

University of Washington

This study illustrates the process of marine environmental education for year-round residents in the San Juan Islands, Washington, by describing and evaluating two marine environmental education projects with contrasting learner groups. One of them is the Forage Fish Project, which educates and involves adult local residents as volunteers in surveying beaches to identify forage fish spawning sites. The other is the Fish Art Project, which used the nearby marine environment as an integrating context for formal education in a 4th, 5th and 6th-grade class in a local school. These programs were evaluated in the information, attitude, and action aspects of environmental education. This study reveals how these programs were planned and implemented, and shows that the learners in both programs were deeply involved in hands-on activities and exposed to the notion of ecosystem. It also shows that these programs have implications for marine protected areas, that they are difficult to sustain because they are small-scale and community-based, and that good use of partnerships contributed to the programs' accomplishments. It provides valuable information regarding what measures are effective and what challenges can be expected in community-based marine environmental education.

Session 1E: CONTAINMENT BURDENS IN FISH

Project Design and Implementation: Bioaccumulative Toxics in Native American Shellfish

Jamie Donatuto

Swinomish Indian Tribal Community

The project represents the logical continuation of researching contamination in water bodies that surround the Swinomish Indian Reservation. Several published reports indicate the presence of chemical contamination in the Tribal tidelands and waters as well as some surrounding areas designated as usual and accustomed (U/A) areas; all of these areas contain sites at which Swinomish people gather shellfish. The central hypothesis of this project states that Swinomish people are exposed to low level, chronic bioaccumulative toxics by consuming local subsistence-

gathered shellfish. The goals of this four-year project are: to ascertain whether the Swinomish people who consume subsistence-harvested clams and crabs are exposed to bioaccumulative toxics to such a degree as to potentially cause chronic and acute health risks; to determine and communicate the health risks; to develop mitigation measures; and, to confirm prominent health conditions and develop hypotheses related to contaminants. The project was initiated in April 2002. Chemicals for which this study will test include: heavy metals, PCBs (poly-chlorinated biphenyls) aroclors and congeners, PAHs (polyaromatic hydrocarbons), dioxins/-furans, tributyltin, and chlorinated pesticides.

The Swinomish Indian Tribal Community is a federally recognized Indian Tribe. Its reservation is located 65 miles North of Seattle, Washington on Fidalgo Island and includes approximately 3000 acres of tidelands.

Persistent Organohalogen Pollutants in Freshwater Fish and Alpine Snowpack in Southwestern British Columbia

Patrick Shaw and Colin Gray

Environment Canada

Despite bans or highly restricted registration of persistent organohalogen pesticides and PCBs, these contaminants continue to be detected in the environment. Concern about the result of atmospheric transport and "cold condensation" into both high latitude and high elevation ecosystems has been mounting. Such a mechanism has produced surprising and toxicologically significant concentrations of these chemicals in "pristine" ecosystems. Westerly flows from potential source areas in Asia and atmospheric release from the North Pacific coupled with the "trapping" effect of high western mountains present a perfect situation for organohalogen accumulation. This survey explored the extent and significance of POPs residues in south west British Columbia through the analysis of selected organochlorine compounds in: 1) fish tissues from remote lakes and reservoirs and, 2) high-elevation snowpack.

Dominant salmonid species were sampled from a total of 17 lakes and reservoirs covering a wide range of physiographic conditions (elevation (0-1435m), watershed basin area/character, bathymetry) in SW BC. Skin-off muscle fillets were analyzed for a range of non-ortho PCB congeners, organochlorine pesticides and toxaphene. Snow samples were collected from a total of 9 high elevation (1200 – 2450m) sites in the mountains surrounding the Strait of Georgia between Vancouver Island and mainland British Columbia. The snow was melted (68-75L total volume), extracted with XAD-2 resin, and analyzed for a suite of PCB congeners, OC pesticides and toxaphene.

PAH Exposure in Marine Fishes of Puget Sound and the Georgia Basin.

Sandra M. O'Neill, James West and Gina Ylitalo

Washington State Department of Fish and Wildlife

We measured exposure to polycyclic aromatic hydrocarbons (PAHs) in several fish species to provide a broad overview of PAH contamination in the Puget Sound and Georgia Basin. Recent PAH exposure was estimated for adult populations of English sole (*Pleuronectes vetulus*), Pacific staghorn sculpin (*Leptocottus armatus*), demersal rockfish (*Sebastes* spp.) and Pacific herring (*Clupea pallasii*) by measuring fluorescing aromatic compounds (FACs) in bile at wavelengths appropriate for benzo[a]pyrene and phenanthrene. For benthic and demersal species, FAC concentrations generally tracked geographic trends in sediment concentrations, with highest exposures in fishes from urban bays in the central Puget Sound, followed by near- and non-urban locations. Within locations with similar degrees of urbanization, FAC concentrations were higher in benthic species than demersal rockfish, possibly because benthic species are more closely associated with PAH contaminated sediments. Pacific herring, a pelagic planktivore, were only sampled at near-and non-urban locations and had higher concentrations in the more urbanized location. These data confirm that measurement of biliary FACs is a useful tool to quantify spatial patterns in recent PAH exposure in marine fish. This type of data can be used to monitor temporal trends in PAH exposure and to assess resource damage in the event of an oil spill.

Contamination with Polycyclic Aromatic Hydrocarbons (PAHs) of Spawned and Ovarian Eggs Of Pacific Herring (*Clupea pallasii*) in Puget Sound, WA

James E. West, Sandra M. O'Neill and Daniel C. Doty

Washington Department of Fish and Wildlife

This study was conducted to evaluate exposure of spawned eggs of Pacific herring to common nearshore toxic contaminants, and to provide baseline exposure estimates from which exposures can be compared after oil spills. We measured PAHs in ripe ovaries taken from pre-spawning wild Pacific herring, and from one- to 10-day-old wild spawned herring eggs removed from spawning substrates. Spawned egg samples represented six of the major Puget Sound spawning stocks; two from Central Puget Sound (Port Orchard/Port Madison and Quartermaster Harbor), two from Northern Puget Sound, but near oil refineries or other heavy industry (Cherry Point and Fidalgo Bay), and two from Hood Canal (Port Gamble and Quilcene/Dabob). We compared concentrations and patterns of 35 PAHs in ovaries with spawned eggs to make inferences about whether PAHs in spawned eggs were maternally or environmentally derived, and to describe geographic trends in exposure of eggs to PAHs. Our results suggest that exposure of spawned eggs to PAHs was environmental (i.e. waterborne), and that site-specific patterns (sources) exist. We observed highest concentrations in eggs from Hidden

Cove, a primary spawning ground for the Port Orchard/Port Madison stock, at levels exceeding an effects threshold. A cooperative study between the WDFW's Puget Sound Ambient Monitoring Program and Oil Spill Response Team, and the Environmental Conservation Division of the National Marine Fisheries Service is planned to investigate the relationship between the PAH exposures and mortality of herring eggs we have observed in Hidden Cove.

Challenges to Establishing Background for Human and Ecological Risk Assessment in Puget Sound and Beyond

Nancy L. Judd, James R. Karr, William C. Griffith and Elaine M. Faustman

University of Washington

Establishing background of contaminants in fish and seafood is a critical task for risk evaluation and management, effecting decisions about resource use and remediation. A proper approach to defining, understanding, and tracking contaminant levels is crucial to human and ecological risk evaluation and risk management. The complexity of the contaminant distributions and sources human (DDTs and PCBs) or of natural origin (mercury, arsenic, nitrogen) requires careful design and implementation of methods to characterize background. Using examples from Puget Sound and other waterbodies, we explore the consequences of different approaches to background characterization. Estimates of background are influenced by sampling and analytical methods such as selection of sampling locations, approaches to data analysis and synthesis, and tissues selected for analysis. Different approaches may yield background exposure or risk estimates that differ by 50% or more. Methodological transparency is essential in data collection and analysis to establish background and to ensure that data are used appropriately in both human and ecological risk assessments. This research was supported by the Consortium for Risk Evaluation with Stakeholder Participation II (US DOE DE-FG26-00NT40938), Center for Child Environmental Health Risk's Research (EPA R 826886-01, NIEHS 5 P01 ES09601-02), and Center for Study and Improvement of Regulation.

Session 1F: NEARSHORE HABITAT MAPPING

Surveying Nearshore Habitat Using ShoreZone and the Rapid Shoreline Inventory

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John Harper

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Helen Berry

Washington Department of Natural Resources

Development along shorelines coupled with the uncertain status of many species that use nearshore habitat has

generated a strong interest in both describing what natural resources occur along shorelines and understanding why they occur there. Two survey approaches are compared: (a) the ShoreZone Inventory method, which is based on aerial overflight imagery and has been applied throughout Puget Sound and the Georgia Basin and (b) the Rapid Shoreline Inventory method that is based on ground observations by citizens groups and has been applied on targeted sections of the Puget Sound shoreline. The type of survey employed ultimately depends on the intended uses of the information.

Due to logistical and cost constraints in measurement, grain (resolution) and extent are strongly correlated such that a large extent survey has a coarse grain (low resolution) while a survey with a small extent can have a fine grain (high resolution). Data content is also correlated with grain such that far more variables are measured in fine-grained studies. The goal of any survey is to accurately describe nature, which itself has a fine grain and a very large extent. These general rules of scale suggest that multiple methods of inventorying natural resources should be employed at different scales to accurately describe natural resources, answer specific research questions, and adequately address management needs.

Using ShoreZone Inventory Data to Identify Potential Forage Fish Spawning Habitat

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John Harper

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The Washington State ShoreZone Inventory provides a consistent, landscape-scale description of marine shoreline components and habitats. In total, the project inventoried 3067 miles of Washington's marine shoreline. The resulting GIS data set includes 50 parameters that describe important physical, anthropogenic, and biological features of the shore zone.

The Inventory data has been used as a planning tool for a multitude of nearshore projects. A recent comparison using ShoreZone beach types and Washington Department of Fish and Wildlife beach spawning data prove ShoreZone data are an effective screening tool for identifying potential forage fish spawning beaches. On the ground survey results show an 88% correlation between actual spawning locale and four ShoreZone beach types. These analyses can generate a map of potential areas of forage fish spawning beaches or focus field investigations thus reducing overall field effort. Further analysis of component data are on-going and will explore more detailed spatial patterns related to distribution of spawning beaches and other shoreline features. The ShoreZone Inventory data set has a wide range of applications for habitat planning, management, and conserving sensitive resources. Many local efforts continue to utilize this information to support more informed decision-making about the uses of the coastal zone.

Use of the Seabed Imaging and Mapping System for Change Detection Monitoring

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Ecostat Research Ltd.

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The Seabed Imaging and Mapping System (SIMS) uses classified imagery that is collected with a towed video system. This system has previously been used throughout the Strait of Georgia (~20 projects) for creating biophysical maps of seabed habitat; typically up to 21 physical themes are mapped (e.g. gravel cover, man-made features) together with 77 biological themes (e.g., eelgrass cover, total vegetation cover, seastar occurrence). A recent survey near Sidney, BC was used to test overall reproducibility including sensitivity of the system to classifier error, and sensitivity to spatial gridding. Multiple classification tests were conducted to estimate inter- and intra-classifier error for a variety of features and species. Grids were surveyed at up to 10m line-spacing and imagery classified. Data were plotted using a variety of grids (e.g., using every line, every other line, every third line) to test sensitivity to grid-spacing. The data provide the basis for defining confidence in mapping resolution and the minimum change in species density that can be detected using this system. The data are relevant not only to our SIMS classification and mapping protocols but to that of ROV or diver surveys.

Nearshore Habitat Mapping of the Central and Western Strait of Juan de Fuca: Preferential Use of Nearshore Kelp Habitats by Juvenile Salmon and Forage Fish

J. Anne Shaffer

Washington Department of Fish and Wildlife

The relationship between juvenile salmonids, forage fish, and kelp beds is not known, but critical to understanding how this dominant feature of Washington and British Columbia nearshore functions. Goals of this study therefore were to: (1) Define kelp bed use by juvenile salmon and forage fish, and; (2) Determine the role nearshore physical features may play in kelp bed use. Our findings indicate that juvenile salmon, surf smelt, and sand lance exhibit complex habitat partitioning within the nearshore. For example, juvenile salmon and surf smelt appear to preferentially select kelp bed habitats over unvegetated habitats, and juvenile salmon appear to select the middle of the kelp surface canopy. Surf smelt show no habitat use partitioning within the kelp bed. While prevalent in the nearshore, juvenile sand lance show no preference for kelp over unvegetated habitats. Physical features appear to also be important for habitat use by these groups of fish. Further defining and understanding these habitat uses is critical for future wise management of these species and the nearshore

habitats that support them, including the use of Marine Protected Areas and kelp bed restoration plans.

Mapping Nearshore Subtidal Biological and Physical Features in Victoria Harbour Using Towed Underwater Video Imagery

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John Harper

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Brian Emmett

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A subtidal inventory of the physical and biological features of the Gorge and Portage Inlet, a shallow, narrow inlet of approximately 110 hectares at the head of Victoria Harbour, was conducted during the summer of 2000. This inventory is part of the Harbours Ecological Inventory and Rating (HEIR) project of the Victoria and Esquimalt Harbour Environmental Action Program (VEHEAP). A towed, underwater video system (Seabed Imaging and Mapping System, or SIMS) was used to obtain extensive, geo-positioned video imagery of the seabed. SCUBA and snorkel observations were conducted to ground truth the video imagery and obtain detailed information on the biotic community and specific seabed features.

The video imagery was subsequently classified by a geologist and a biologist and seventeen physical and biological themes, including substrate type, organic debris, vegetative cover, macroinvertebrates, were mapped in GIS format and posted on the VEHEAP website along with geo-positioned video imagery. Within Portage Inlet and the Gorge Waterway, the survey mapped approximately 80 hectares of eelgrass (*Zostera marina*) beds as well as regionally significant areas of abundance of native oysters (*Ostrea conchaphila*). This paper will review the SIMS technology and mapped biophysical features, demonstrating the thematic information available through the VEHEAP website.

Nearshore Habitat Mapping in Hood Canal Using Underwater Video and Hyperspectral Imaging

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Earth Design Consultants, Inc.

Charles Simenstad

University of Washington

Jim Norris

Marine Resources Consultants

Comprehensive, fine-scale resolution intertidal-subtidal eelgrass habitat maps were developed near the vicinity of the Hood Canal Floating Bridge as part of the Washington State Department of Transportation's plan to repair and replace portions of the Bridge. The project delineated eelgrass and other habitats using a combination of

georeferenced underwater video for the subtidal portion and Compact Airborne Hyperspectral Imagery (CASI) data for the intertidal portion. Each mapping technology was applied at different times of the year in the same general study area, with some spatial overlap. Sufficient resolution and precision existed to link both methods, providing a mosaic of comprehensive intertidal-subtidal eelgrass habitat. Subtidal underwater video transect data consisted of ~14,000 observations that were post-processed and classified for eelgrass density, substrate type, fish and macroinvertebrates. CASI imagery was collected along two flightlines covering the intertidal and shallow subtidal habitats. Eight intertidal landcover types were developed from the CASI imagery including dense eelgrass, sparse eelgrass, green algae, sparse green algae, brown algae, sand, gravel/cobble, and oyster shell/gravel. Correspondence in eelgrass delineation in the lower intertidal area of overlap between the two mapping methods was 86% and 95% for sparse and dense eelgrass, respectively. We believe this mosaic of intertidal-subtidal eelgrass habitat is one of the first integrated mapping efforts using underwater video and hyperspectral imaging.

Session 2A: CULTURAL RESOURCE MAPPING

The Sto:lo Coast Salish Historical Atlas: Resource Information as The Foundation for Decision-making

Sonny McHalsie

Sto:lo Nation

The Sto:lo are the River People, a Coast Salish group that lives along the lower stretches of the Fraser River watershed in an area now called the Lower Mainland and Fraser Valley. The Sto:lo Coast Salish Historical atlas was created as a brilliant survey of the traditional territory of the Sto:lo First Nations people, including the lower Fraser Valley and Metro Vancouver. This ground-breaking historical atlas, the first produced by a Canadian aboriginal organization, contains information about the history of a First Nations people and their homeland, and depicts in maps, archival photographs and words the mythic beginnings of the Sto:lo people and the effects of white settlement that turned their homeland into a major urban area. Using material drawn from the larger Coast Salish region, the atlas covers southwestern British Columbia and northwestern Washington state, including metropolitan Vancouver. The atlas has three sections that deal with different themes derived from Sto:lo history, cosmology and the physical landscape of their homeland. The material which formed the basis of this atlas highlights significant changes that urbanization has had on watersheds, and the tools that the Sto:lo Nation have comprised in the compilation of this resource provide significant background materials for the consideration on planning and visioning tools.

Collaboration as a Starting Point—Ashkui a Cultural Landscape Unit

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Environment Canada

Trudy Sable

Saint Mary's University

Jack Selma

Innu Nation

Geoff Howell

Environment Canada

Over the past several years, the Innu Nation, Environment Canada, the Gorsebrook Research Institute of Saint Mary's University and Natural Resources Canada have been exploring new ways to connect Innu knowledge and western science. Our approach uses the conceptual category of a Cultural Landscape Unit (CLU) as the basis for generating new knowledge about the biophysical make-up of Labrador. This method starts with Innu knowledge and terminology for an element of the landscape that has value and meaning for them and then builds a knowledge base of that feature from a number of perspectives. Our hypothesis is that a combined form of ecological knowledge can be developed that recognizes the qualities and limitations of Innu and Scientific knowledge systems and situates both within the specific context of the times they are produced in. Fieldwork conducted Innu from Sheshatshiu examined areas known as ashkui in the Innu language. Ashkui are areas of early or permanent open water on rivers, lakes and estuaries. The original concept for this initiative was developed at a planning meeting in Sheshatshiu hosted by the Innu Nation where the ashkui landscape element was identified by Innu elders as being of primary importance. Collaboration was the starting point of this research. Choosing our partners, and then determining the research direction has been one of the main contributions that this project can showcase as a focus.

Session 2B: CLIMATE CHANGE (II)

Climate Change: Will Our Weather Become More Extreme?

Francis W. Zwiers

Meteorological Service of Canada

I will first briefly review some of the accumulating evidence that our climate is changing. I will then discuss the factors that are thought to be causing a substantial portion of the observed changes and will describe the tools (climate models) that are used to test our understanding of these factors. We will also discuss projections of future climate change obtained from global climate models and some of the resulting implications for climate and weather extremes.

An End-to-End Assessment of Climate Change Impacts on Water Resources in the Western North America

L. Ruby Leung and William T. Pennell

Pacific Northwest National Laboratory

The Accelerated Climate Prediction Initiative was funded by the U.S. Department of Energy to develop the scientific knowledge and computational infrastructures needed to carry through an end-to-end assessment of the possible effects of human-induced climate change. To demonstrate the feasibility of the end-to-end approach, a regional climate model was used to downscale an ensemble of global climate simulations of the present (1995-2015) and future (2040-2060) that follows a business as usual scenario for carbon emission. The regional simulations were used to drive a set of hydrologic models to study the impacts of climate change on water resources in river basins of the West. Results show that by mid-century, the average regional warming of 1-2.5°C strongly affects snowpack in the western North America. Along coastal mountains, reduction in annual snowpack was about 70%, which is accompanied by 15-20% increase in cold season extreme daily precipitation. Overall, by mid-century, there is a higher likelihood of wintertime flooding and reduced runoff and soil moisture in the summer. Such changes could have serious impacts on water resources and agriculture in the western North America region. More specific analyses of climate change effects for the Georgia Basin/Puget Sound region will be presented.

Hydrologic and Climatic Impacts of a Changed Climate on Georgia Basin, British Columbia

Christopher J. Reynolds

Earth Mirror Consulting

The present study considers the hydrologic and climatic impacts of a changed climate on 6 watersheds representing the dominant runoff forms of Georgia Basin, British Columbia: rain dominated [pluvial], snow dominated [nival], and hybrid—a combination of rain and snow. It considers the climatic and hydrologic processes in regards to changes in the length of the wet/dry and warm/cold seasons and the resulting hydrologic characteristics of streams that can be expected. Through the use of the UBC Watershed Model, it is possible to provide a forecast of the possible changes in the hydrology of the Georgia Basin in this future climate. The climatic input for the modeling came from the Canadian Global Coupled Model (CGCM1). Twenty-one year time slices (1973-1993, 2013-2033, 2043-2063, 2073-2093) were chosen from the CGCM1 to simulate how climatic and hydrologic conditions will change over the next hundred years within the basin. Under a changed climate, the hydrological response varies significantly depending on the basin's dominant form of winter precipitation. The simulation results indicate that rain driven systems will have higher winter streamflow driven by greater winter rains. Watersheds that are now

snow driven will experience a shift toward more of a hybrid-type flow regime. While hybrid watersheds, which are currently controlled by winter rainfall and by summer snowmelt, will see the most significant annual changes showing a strong transition towards winter rainfall driven runoff.

Modelling Streamflows in Present and Future Climates—Floods and Droughts in Georgia Basin

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Environment Canada

The Georgia Basin is one of the most hydrologically complex areas of Canada. Variations in temperature and precipitation exert tremendous influence on the amount and form of water that reaches the surface of Georgia Basin. The form in which precipitation occurs in winter, either snow or rain, determines the hydrologic patterns of rivers. The region consists of both coastal and inland areas, and landforms such as mountains, valleys, and plains at various elevations. This amalgamation of various climatic and geographical factors has led to there being homogenous zones in which distinctly different hydrological processes occur. Climate change could have major regional effects on temperature, precipitation, evapotranspiration, and ultimately runoff. In previous work we delineated zones of homogenous hydrologic processes. The potential changes in extremes, namely floods and droughts are reported.

Climate Change, Infrastructure and Stream Health in an Urban Catchment

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Stationarity of rainfall statistical parameters is a fundamental assumption in hydraulic infrastructure design that may not be valid in an era of changing climate. This study develops a framework for examining the possible impacts of climate change on the urban infrastructure and natural ecosystems of small watersheds, and demonstrates this approach for the Mission/Wagg Creek watershed in British Columbia, Canada. Non-stationarities in rainfall records are first analyzed with linear regression analysis, and the detected trends are extrapolated to build future rainfall scenarios. The Storm Water Management Model (SWMM) is used to analyze the effects of increased rainfall intensity on design peak flows and to assess future drainage infrastructure capacity. Future impacts on stream health are assessed using methods based on equivalent total impervious area. In terms of impacts on the drainage infrastructure, the results of this study indicate that climate change would not create severe impacts in the Mission/Wagg Creek system. The equivalent levels of imperviousness, however, suggest that the impacts on stream health could be far more damaging.

The Vulnerability of Lower Englishman River Floodplain to Modeled Climate Change

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Reynolds, C. J. (2002), conducted research that considers the hydrologic and climatic impacts of a changed climate on Englishman River on the East Coast of Vancouver Island. The study considers the climatic and hydrologic processes in regards to changes in the length of the wet/dry and warm/cold seasons and the resulting hydrologic characteristics of streams that can be expected. Results indicate that the rain driven system will have higher winter streamflows caused by greater winter rains and lower summer flows caused by lower winter snowfall

The present study investigates the changes to the hydrologic regime of the Lower Englishman River Floodplain that will occur if the results of the Reynolds study are realized. Specifically, what is the effect of the changed hydrologic regime on: the flood plain boundary limits and return intervals of the current 20 and 200 year floods, the current summer low flows, and erosion of and deposition within the current channel and channel banks.

The basic methodology of the present study will involve input future runoff scenarios into the river rating curve to get future 20 and 200 year flood elevations. The predicted 20 and 200 year flood elevations will be plotted by hand onto existing 20 and 200 year flood plain mapping. From this new map, we will determine which areas of the flood plain are vulnerable and attempt to predict impacts.

With increased flood levels and flood frequency, the floodplain will flood with higher magnitude and frequently than in the past. Decreased summer flows will lead to dewatering of the river channel. Increased channel and bank erosion, avulsion and sedimentation may occur; private property and public infrastructure will be affected.

Session 2C: PLANNING IN URBANIZING HABITATS

Buffers and Setbacks in Marine Environments: A Review of Three US/Canadian Coastal Areas and Their Approach to Coastal Management

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Puget Sound Action Team

Jim Brennan

King County Department of Natural Resources

Riparian buffers and setbacks are commonly used as a management tool in the United States to protect water

quality, control erosion, and enhance wildlife in freshwater systems. Setbacks and buffers, whose effectiveness in freshwater systems is well documented, have been used as a Best Management Practice in forestry and agriculture since the 1950s and, more recently, have been used to control and abate Nonpoint Source Pollution (Desbonnet et al, 1993). Although U.S. coastal areas are experiencing problems similar to those of freshwater systems, little research has been done to document the functions and values of marine riparian vegetation. Our first paper, 'An Assessment of Riparian Functions in the Puget Sound Nearshore Ecosystem', was written to develop a rationale and provide a review of riparian functions as they relate to the marine environment.

This paper builds on our first paper by providing additional information from recent riparian-related research and a regulatory overview of U.S. laws governing the coastal zone. The purpose of this paper is to begin to develop a framework for a discussion of marine riparian buffer and setback policies in Puget Sound and the Georgia Basin. We provide an overview of the current regulatory situation in Puget Sound and the Georgia Basin as it relates to the marine riparian zone. We also provide an overview and comparison of two areas in which marine riparian buffers and setbacks are used as a management tool: Chesapeake Bay and Rhode Island. This comparison includes an overview of the goals and management objectives for each region, implementation strategies, and, where possible, their successes and/or failures in achieving their goals and objectives.

Planning Property Acquisitions and Protection for In-Stream Habitat Protection: A Parcel Based Ranking of Opportunities in South Prairie Creek

Chris Davis

Commen Space

Productive salmon habitat is the product of a variety of processes, some of which are principally aquatic while others are terrestrial. Watershed land use patterns, access to historical side channels and flood plains, and riparian conditions are only some of the many physical measures that have been studied in an effort to quantify the relationship between landscape condition and in-stream habitat. In an effort to guide the land protection initiatives or a regional land trust, we conducted a parcel -based analysis of landscape conditions in South Prairie Creek in Pierce County. Additional data quantifying relative risk of future development of parcels contributing to functional habitat were developed and incorporated with biological data to prioritize lands for protection. This study suggests some methods for addressing the difficult spatial relationships that tie disparate land use patterns to aquatic conditions and incorporates planning and land use data into results being used to support further requests for land protection.

A New Approach to Quantifying the Effectiveness of Riparian Buffers in the Rural-Urban Fringe

Lea Elliott

University of British Columbia

The importance of riparian buffers in the protection of salmonid habitat and water quality is widely recognized. Buffers minimize nutrient runoff, increase bank stability, moderate stream temperatures and increase stream habitat complexity. It is difficult, however, for managers to prioritize buffers for protection and restoration. This study investigates a number of easily measured indicators that can be used to predict the effects of riparian vegetation, land use and soil characteristics on water quality and fish habitat. The percentage of vegetation cover, land use types and soil drainage characteristics were sampled using a Geographic Information System at a variety of scales. These characteristics were compared with water quality and physical fish habitat parameters sampled in the field. Preliminary results show higher stream temperatures in areas of less tree cover, higher nutrient levels in areas with more agricultural land use and higher nutrient levels in areas with more rapidly draining soils. Ultimately these indicators will be integrated into a buffer effectiveness rating system that can be used by local communities and decision makers to set protection and restoration priorities.

Green Links and Urban Biodiversity—An Experiment in Connectivity

Valentin Schaefer

Douglas College

Cities often occur in biologically important natural areas. The ecosystem fragments that survive urbanization become increasingly isolated with reduced biodiversity and viability. These fragments may be more important than their limited size and disturbed plant life might suggest. Urban forests play a crucial role in maintaining water quality, loafing grounds, feeding grounds, perch sites, ambient temperature and buffer strips. Small wetlands may be vital to thousands of migrating birds.

One solution to the problem of habitat fragmentation is connectivity. Fragments are connected by corridors of green space, enabling them to function as larger units with larger breeding populations and more complex food webs.

Green Links, a project of the Douglas College Institute of Urban Ecology, establishes ecological corridors throughout Greater Vancouver, British Columbia. Plantings of native vegetation are focussed on utility rights-of-way, parks, boulevards and backyard habitat. Community involvement and changes in community values through environmental education are integral to the project.

Since 1996 Green Links has created corridors with over 40,000 plants and hundreds of kilograms of seeds. This has involved 5,000 community participants and has been

supported by 15,000 people attending workshop and lectures.

Trout, Transit, and Town Centres: GIS and Web Applications for Integrating Fish into Complete Community Planning

Robyn J. Wark

City of Burnaby

In Georgia Basin and Puget Sound communities, land use planners and engineers are seeking ways to protect fish habitat while creating complete, sustainable, and livable communities. This paper reviews approaches used in the City of Burnaby, British Columbia to more closely understand fish habitat requirements, limiting factors to fish, and habitat enhancement opportunities. This limiting factor analysis has been conducted for specific streams throughout the municipality, and is linked to a Geographic Information System database. The database will also include information on water quality monitoring, pollution events, and fish releases. The City is working to make the mapping and data available to City staff, developers, and the general public through a web-based mapping application. The paper discusses how this layer of information can be used to inform local area plans, such as a transit-oriented town centre plan. The mapping allows planners, decision-makers, and the public to more clearly understand trade-offs and opportunities for habitat protection and enhancement during community planning processes.

Session 2D: REGIONAL CONSERVATION PLANNING

Environmental Implications of Transboundary Protected Areas and Matrix Lands

James Allaway

Western Washington University

Michael Medler

Western Washington University

The North Cascades transboundary complex of parks and other protected areas (PPAs), together with a surrounding matrix of public and private lands, contains the upper watersheds of an important part of the Georgia Basin/Puget Sound region. This research aims to contribute to understanding how management policies and practices on these protected areas and surrounding lands affect natural ecological processes and the achievement of PPA objectives.

Key management issues include those that have high ecological influence, vary between land ownerships and jurisdictions (especially across the international boundary), and are currently undergoing development or refinement. This research initially focuses on three issues: fire management, reintroduction of animal species especially

large predators, and regulation of human settlement.

As the pilot phase of a longer term project, this research:

- (1) Compiles an inventory of PPAs and surrounding matrix areas in a part of the study region to test the approach.
- (2) Categorizes and reviews management policies and practices, and environmental indicators.
- (3) Examines links between management and the status of ecosystem processes.
- (4) Identifies topics for further investigation.

Data are gathered by literature review, GIS data base compilation and analysis, and interviews with land managers and interest groups.

The Role of Local Ecological Knowledge in Effecting Political Decisions: Lessons from McFadden Creek, Salt Spring Island

Katherine Dunster

Dunster & Associates Environmental Consultants Ltd.

In June 2002, the Salt Spring Island Local Trust Committee turned down an application to re-zone an intertidal area and expand a shellfish aquaculture operation at McFadden Creek Estuary on the northeast end of Salt Spring Island. The nearby McFadden Creek Heronry is owned by the Islands Trust Fund, and managed by the local Waterbird Watch Collective.

In the two years preceding the June 2002 public hearing, planners had erroneously assumed that the critical issue was ensuring that the rezoning would have little impact on the Great Blue Heron (*Ardea herodias fannini*). By taking a single-species planning approach, the needs of other parts of the ecosystem were ignored, and the staff recommendation was to proceed to rezoning. Local ecological knowledge presented by members of the community at the final public hearing provided the politicians with a fuller picture of how the ecosystem functions, the inter-connectedness of species, the interface between terrestrial and marine ecosystems, and the need for informed ecosystem-based decision-making. The decision to reject the rezoning application affirmed the wisdom of the community, and set a precedent for future scenarios in the Islands Trust Area.

This paper will describe the planning process, discuss the critical flaws, and present the case for ecosystem-based decision-making as it was used in the McFadden Creek Estuary re-zoning application.

Nearshore Marine Ecoregional Planning

Zach Ferdaña

The Nature Conservancy of Washington

Curtis D. Tanner

U.S. Fish & Wildlife Service

Paul Dye

The Nature Conservancy of Washington

Michael W. Beck

The Nature Conservancy

The Nature Conservancy is an international, nonprofit organization dedicated to conserving biological diversity. In the past decade we have increased our focus on critically important coastal and marine ecosystems, and now work at more than 100 sites around the world. As we work to dramatically increase our contribution to marine conservation, one of our primary tools is ecoregional planning.

The Conservancy has been building methods for analyzing the nearshore environment within the Willamette Valley—Puget Trough—Georgia Basin ecoregion. Using data sets from collaborating scientists and public agencies, we have developed a conservation portfolio incorporating ecosystems down to 40 meters below mean high water. We used shoreline data as an ecosystem representation filter, and relied heavily on forage fish spawning grounds, rockfish, rocky reef, and seabird information for species analysis. An optimal reserve selection algorithm called SITES was used to select areas using hexagon planning units in the nearshore, and a linear unit for the shoreline.

Marine experts in Washington and British Columbia reviewed draft portfolios and we incorporated their knowledge of high quality sites into a “first credible iteration.” By using similar methodologies across terrestrial and freshwater environments we were able to develop a fully integrated blueprint for biodiversity conservation in the region.

The Salish Sea Community Mapping Project

Sheila Harrington, Briony Penn, Judi Stevenson or Kathy Dunster

The Land Trust Alliance of British Columbia

Accompanied by a slide presentation of more than 30 artistic community maps, we will describe this innovative regional community mapping project. The Islands in the Salish Sea Community Mapping Project has brought over 17 island communities together to gather, collect and present local and scientific knowledge in the form of artistic community maps. This collaboration has increased the capacity of these island communities, in terms of mapping skills and the power these maps have, especially in order to influence decision-makers and to cross boundaries between community values, art and science.

- The project has initiated new 2000 state of the island inventories from 17 island communities

- The mapping process, involving community workshops, public events, interviews and information-sharing sessions, has increased local and regional knowledge of island culture, economies, energy & transportation needs, habitats and species in the Strait of Georgia
- The exhibition of the collection of over 30 maps has toured all the islands, and has developed a significant increase in awareness of common ecological and cultural issues among island residents and a new sense of regional identification
- Four regional maps form part of the collection; at least two of which will be complete by the date of the Forum: terrestrial & threatened species, energy and transportation, marine, and economics.

The session will be valuable to planners and policy-makers working for sustainable development in the islands within the Georgia Basin region. The session will also be of particular interest to scientists wishing to include more community knowledge in their research, and for those wishing to develop more innovative and inclusive ways of presenting their research results.

An Analytical Approach for the Evaluation of Critical Habitat Issues for Wide-ranging Nearshore Marine Species

Glen Jamieson, Brad Mason and Ed Gregor

Fisheries and Oceans Canada

Canada's imminent Species at Risk Act (SARA) requires that "critical habitat" be defined and protected for endangered and threatened-listed species. "Critical" habitat for some marine species may be relatively well defined (e.g. estuarine species), but many widely-distributed nearshore listed species (e.g. northern abalone, sea otters, etc.) occur now, or have occurred in the past, at countless places over much of the coastal region, with specific concentrations presumably determined by topography-bathymetry, substrate, and predator occurrence / food availability. Whether any specific large section of shoreline is more important, or critical, than others as habitat for any specific species is debatable. For such widely distributed species, relevant management/conservation questions may focus more around 1) the overall percentage of the coast that merits particular conservation (dependent on objectives) for a given species, and 2) its optimal spatial pattern of distribution (e.g., source populations, occurrence in existing protected areas, above-average areas of abundance, proximity to fisheries, etc.) so as to include adequate local species concentrations.

Here, we present an approach that we believe can help address the issues presented above. Species-unique rules re habitat suitability may determine areas of localised species concentrations, and these rules may be deduced and assessed by comparing model predictions using various hypothesised rules against actual observations of a species' micro-distribution where its known. To ensure

transparency and consistency, and to avoid duplication of effort by different researchers, the overall database to which such rules would be applied should be common to researchers working on all coastal species. It would contain both relevant existing physical (shoreline shape, bathymetry, depth, substrate, currents, wave exposure, etc.) and biological (geo-referenced densities and abundances, seasonal occurrence, etc.) data for study species, and as much as practical, their predators and food sources. This common DFO database should incorporate research, fishery-dependent and local ecological knowledge (LEK), and by definition, will be an evolving, dynamic entity.

In addition, we summarise the deliberations of a Critical Habitat Workshop to address these issues that took place in early 2003.

Session 2E: MARINE BIRDS: CONTAMINANTS, HABITATS AND CONSERVATION

Assessing Southern Strait of Georgia Marine Bird Population Changes Since 1980: What We Know and What We Need to Know

John L. Bower

Western Washington University

The most comprehensive marine bird census of southern Strait of Georgia and surrounding waters was the Marine Ecosystems Analysis Puget Sound Project (MESA) conducted during 1978-79.

Since that time, census work has been limited to Christmas Bird Counts, twice-a-year airline flights during the 1990's, censuses of breeding islands, and work focused on marbled murrelets. While these studies have suggested dramatic population changes for some species, their geographic, methodological, and/or temporal limitations have prevented more comprehensive conclusions from being drawn. Here I assess our current state of knowledge about inshore marine bird populations. I also report the methods and preliminary findings of a new study designed to replicate important features of the 1970's MESA study with the goal of strengthening our knowledge about recent changes in local marine bird populations.

Wings Across the Border: Lessons from Heron Conservation in the Georgia Basin and Puget Sound

Rob Butler

Environment Canada

The Georgia Basin and Puget Sound hold very important bird habitats in the Americas. Cooperation is essential for region-wide conservation where much of the land is in private ownership and much of the research is done by

governments and universities. One of the most studied animals in the region is a resident subspecies of Great Blue Heron uniquely adapted to the Pacific Northwest. This paper describes the scientific results that have supported the evolution of a transboundary conservation policy for herons.

Pairs to Plenty: COASST's Monitoring and Partnering Patterns

Todd Hass and Julia K. Parrish

University of Washington

COASST (Coastal Observation and Seabird Survey Team) is a citizen-science program partnering local residents, scientists, and natural resource managers through collection and use of information on beached birds throughout the coastal Pacific Northwest. The principal goals of COASST are: (1) development of a high-quality baseline against which change in nearshore environmental health, as exemplified by marine birds, can be assessed, and (2) hands-on marine biology education of coastal citizens. Within our program we've created a wide network (>150 volunteers monitor at least monthly throughout Washington and Oregon) of citizen stewards - active participants in coastal marine resource management and protection. Beyond these stewards, we've also built strong alliances with other like-minded agencies and NGO's in the US and Canada. For example, we've helped to establish comparable new beached bird programs in BC and eastern Canada with Bird Studies Canada and the Canadian Wildlife Service. In this talk we will discuss our ongoing successes in gaining new pairs of volunteers, our partnerships with other organizations, and our discoveries in environmental monitoring in the Pacific Northwest. For further information, please visit www.coast.org.

Conserving and Monitoring BC's Coastal Landbirds

Shawna Pelech and Wendy Easton

Canadian Wildlife Service

Partners in Flight is a multi-partnered initiative with a vision to maintain the health of bird populations and their habitats. Partners in Flight uses regional data, local expertise, and international standards to determine conservation priorities and develop and implement regional conservation plans. BC and Yukon Partners in Flight has identified 67 priority landbird species for Canada's Northern Pacific Rainforest, and from these has selected a subset of focal species to help provide management recommendations. The needs of these species could be incorporated in new and existing partnerships such as the Pacific Coast Joint Venture and Georgia Basin Ecosystem Initiative. Improved monitoring of coastal landbirds will be integral to successful conservation efforts. Many priority species are declining, some are extirpated, but for many others population trends and status are unknown. Rocky Point Bird Observatory on Vancouver Island has been monitoring both breeding and migrating birds in Garry Oak Meadow and Coastal Douglas-fir ecosystems since 1994 and trail breeding and migration monitoring has been

initiated recently at Alaksen National Wildlife Area south of Vancouver. Data from these monitoring programs will help evaluate the status of BC's coastal landbirds, and efforts are underway to link results with other coastal monitoring stations in North America.

Modeling Waterfowl Use of BC Estuaries Within the Georgia Basin to Assist Conservation Planning and Population Assessment

John L. Ryder

Ducks Unlimited Canada

Estuaries are among the most threatened areas in British Columbia owing to continued coastal development, modification, pollution and the potential effects of climate change and they are of critical importance to tens of thousands of wintering waterfowl. There are an estimated 600 estuaries in B.C., but they have yet to be mapped and classified using standardized criteria, and the waterfowl populations they support have yet to be fully assessed. To address these deficiencies, we are developing a spatially explicit model combining a standardized classification of estuaries at the scale of the Georgia Basin with site-specific analyses of waterfowl survey data. The objectives of the model are to:

- (1) Generate a GIS layer of estuaries found within the Georgia Basin, using standardized classification and mapping criteria.
- (2) Determine which physical and habitat attributes best predict waterfowl abundance on estuaries.
- (3) Predict the waterfowl populations likely to occur in estuaries based on their habitat features.

This assessment will provide a GIS reference identifying our conservation interests in estuaries to be used by stakeholders, and it will assist in prioritizing the planning and habitat securement initiatives undertaken by the Pacific Estuary Conservation Program (PECP).

What Can Physiology Tell Us About Stopover Site Habitat Quality for Migrating Western Sandpipers?

Dana A Seaman, Tony D. Williams , Robert W. Elner

Simon Fraser University

Christopher G. Guglielmo

University of Montana

The ultimate expression of the quality of a site is in the condition of the individuals using it. In migratory birds, success of migration is linked to the rate of fat deposition at stopover sites. Therefore fattening rates can serve as an index for habitat quality of migratory stopover sites. Size-corrected body mass has been used as an index for body condition, but only provides information at a single point in time. Previous studies by our group have shown that plasma triglyceride concentrations can predict mass change in free-living birds and provide information on the physiological condition of birds. In this study, we demonstrate significant

site differences in fattening rates in migrating Western Sandpipers (*Calidris mauri*) at stopover sites within the Georgia Basin/Puget Sound based on metabolite analysis. Stronger site effects were detected during northward than southward migration. There was within site consistency between seasons and years. There was no site effect in size-corrected body mass, i.e. metabolite data provide information not obtainable by mass data alone. There was a positive relationship between triglyceride levels and prey abundance. Future work will explore correlations with other underlying ecological factors that may explain the remaining variation in fattening rates.

Session 2F: INFORMATION AND DECISION SUPPORT TOOLS FOR THE MARINE ENVIRONMENT

Automated Monitoring Protocol

Boyd Brown and Nancy Liesch

Ministry of Sustainable Resource Management

Procedures are introduced to automatically update a website for land use sustainability monitoring each time the inventory base data is updated. The Automated Monitoring Protocol provides a systematic approach to unbiased, comprehensive and timely reports on natural resources sustainability. The protocol consists of 3 procedures:

1. Workshops to capture the relationship between resource data and monitoring reports.
2. Detailed data flow logic documentation.
3. An automation tool for public access to relevant information.

A pilot project in the Bulkley Land and Resource Management Plan area provides a 37-page biodiversity monitoring report accessible with an internet compliant Visual Basic program. Improved website capability and other LRMP values are under development.

The approach of scripted data modelling and evaluation of plan values has wide application in any value set where inventories are periodically updated. Automated monitoring ensures comparable results over time for trend analysis. This website tool presents the integration and access of spatial data and non-spatial data using ArcIMS and therefore resultant PDF documents, images, tabular results and the ability to generate current results via the internet are available in a user-friendly and effective manner. Our efforts to reach sustainability are now available for the world to see.

Using Internet-based Mapping to Improve the Accessibility of Intertidal and Backshore Inventory and Ecological Evaluation Information for Victoria and Esquimalt Harbours

Brian Emmett

Archipelago Marine Research Ltd.

David Harper

Westland Resource Group

Steven Myhill-Jones

Latitude Geographics Group Ltd

Mary Morris and Pam Thuringer

Archipelago Marine Research Ltd.

The Victoria and Esquimalt Harbours Environmental Action Program (VEHEAP) is a multi-agency group implementing an environmental action plan for Victoria and Esquimalt Harbours. A key element of the program is the Harbours Ecological Inventory and Rating (HEIR) project, which consists of a systematic inventory of the backshore and intertidal features of the harbours and a subsequent ecological rating of these features. The intent of the HEIR project is to support more ecologically sound land and water planning decisions.

An inventory of intertidal and backshore features of the harbour was conducted in 1998, and a five point, qualitative ecological rating (very high, high, medium, low, very low) of these features carried out using four evaluation criteria (species diversity, habitat diversity, natural habitat, and presence of key life cycle requisites). The information was initially presented in conventional report and map folio format, and the supporting inventory data was available by requesting that VEHEAP provide the complex database or GIS output. In 2002 the HEIR inventory was revised and updated with the objective of producing results that are more accessible and easily distributed to harbour management agencies, municipal planners, land owners and community groups. To achieve this objective, the database and GIS mapping products were extensively revised and deployed as an Internet mapping (ArcIMS) site to allow the user to readily access the database components, including the underlying rationale for the ecological evaluation ratings. This paper will demonstrate the ArcIMS product and discuss the role of this environmental management tool in planning for and management of foreshore areas.

Enhancing the Planning Process through Science and Adaptive Management

Darryl Low Choy

Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, Australia

The paper outlines the results of an environmental planning research project that examined various planning processes utilised by private and public sector managers for the development of plans, policies and management actions seeking community water quality objectives for a region's

waterways and coastal embayments. The planning agents included:

- Local government in the preparation of their statutory planning schemes and their environmental policies;
- State government agencies in the preparation of plans and policies; and
- Landowners (Freehold tenure) in the preparation of property management plans.

A generic cyclic planning process comprising two distinct phases, a plan-making phase and a plan-implementation phase, has been proposed. The latter phase includes an adaptive management approach that facilitates broader community involvement in the planning process. The project has also raised the notion of the introduction of civic science into the planning process alongside of the greater utilisation of conventional science. In this latter regard, the project has developed “roadmaps” for the enhancement of a range of statutory and voluntary planning tools through the incorporation of biophysical science.

Expert Systems Applied to Marine Oil Spill Response Operations

Gerald Graham

Worldocean Consulting, Ltd.

This presentation assesses the potential for ‘expert systems’ as one way of reducing the threat of marine oil spills in the Georgia Basin/Puget Sound region. Over 15 billion gallons of oil moved in and out of the area in 2000.

Expert systems in effect transfer the knowledge of an expert to a computer. Over 15,000 of them have been developed so far. Their general features, strengths and limitations are examined first, along with examples of their application. There follows an assessment of their worldwide application to oil spills, and the prospects for their further development.

Expert systems can save precious time in the event of a catastrophic spill, but can be complicated and costly to develop. Simple decision support tools can, however, be designed that are both cost-effective and practical.

Oil spill recovery techniques have basically stagnated for thirty years—typically, only 5 to 15 percent of oil spilled on the water will be recovered. Information technology offers some hope of improving that record by speeding up decision-making and potentially preventing costly environmental damage. Consideration should therefore be given to supporting innovative R&D in the Georgia Strait/Puget Sound basin into expert systems, as an innovative approach to problem-solving and emergency management.

Session 3A: REGIONAL ECOSYSTEM- SUSTAINABILITY INDICATORS

Applying Science to Community Interests: Promoting Change Through User-friendly Environmental Indicators

Michelle Carr and Shane Ford

*Land Based Habitat Subcommittee of the CRD
Roundtable on the Environment*

This session will describe two environmental indicator projects undertaken by members of the Capital Regional District (CRD) Roundtable on the Environment: (1) a brochure and map that identifies the percentage of impervious surface cover in six Greater Victoria watersheds and discusses implications for ecosystem health and stormwater management, and (2) a fact-sheet and map that identifies the percentage of Sensitive Ecosystems Inventory polygons that are found inside and outside parks in the CRD. The goals of the projects were to use science-based environment and growth indicators to promote awareness of growth issues, affect change in individual and collective behaviour, and promote informed local government decision-making. A further assessment and development of indicators for the Capital Regional District is planned.

By promoting science through user-friendly indicators, the Roundtable is able to present information on complex and politically sensitive urban development issues in a neutral manner. Indicator results will enable municipalities and the community groups to prioritize conservation and restoration efforts. The broader implications of these projects include greater awareness of urban ecosystems, support for informed decision-making at the local level, and support for indicators as a barometer of the implications of urban development.

Building Community Sustainability Indicator Reports

Brent Mueller

BC Ministry of Community

This paper will substantially draw on the experience and results of a provincial pilot initiative to help BC communities develop locally relevant ways of measuring their progress towards sustainability. Two of the pilot projects were within the Georgia Basin region—New Westminster and Sunshine Coast; and two were outside of the region—Clayoquot Sound and Quesnel. It assumes that making progress towards sustainability requires local level approaches. This paper will examine key factors in developing a local sustainability indicator report that can lead to action. Key points to be raised and discussed include:

- How communities can use “science” or indicator data provided by experts to better understand local environmental, social and economic conditions.

- The value of having community indicator project managed by a steering committee of local leaders so people of diverse backgrounds, with resources, can share perspectives to develop a common understanding of local conditions and issues.
- The appropriate role of higher levels of government in terms providing support, mentoring and data to help communities build local reports.
- The importance of ensuring that indicator reports include both positive and negative trends so that communities understand where they need to make progress and what they need to protect.

Sustainability Indicators for the Fraser Basin— A Tool for Change

Steve Litke

Fraser Basin Council

The Fraser Basin Council has developed a set of indicators to measure the state of sustainability in the Fraser Basin. The indicators will help facilitate progress towards sustainability by engaging basin residents and stakeholders in developing collaborative actions to address current sustainability trends. The Council developed its indicators by researching indicator initiatives, soliciting expert advice, and through dialogue with government, civil society, the private sector, and the general public. An advisory committee assisted in data collection and analysis.

The Council will present 16 headline indicators in a “State of Sustainability” report to be released in January 2003 at the “State of the Fraser Basin” conference. These key indicators are easily understood and reflect issues of broad concern. Additional indicators and case studies will add insight and broaden the scope of analysis within the report. There remains a need to enhance the availability and quality of indicator data over time if indicators are to continue to be a useful tool for change. This will require further dialogue and collaboration among many partners interested in—and responsible for—the collection and analysis of information about sustainability. Ongoing cooperation, coordination, and networking among indicator practitioners would also strengthen future indicator work.

Issues in Ecosystem-based Measurement for the Georgia Basin-Puget Sound Region

Geoffrey Thornburn

Georgia Basin Ecosystem Initiative

Heidi Siegelbaum

Washington State Department of Ecology

Managing ecosystems that cross political and particularly national boundaries can benefit from common, or at least compatible, data and indicators. Transboundary reporting can also help bring shared environmental issues and their causes to public attention and thereby prompt policy and behavioural responses to the trends or conditions reported.

The first published set of transboundary environmental indicators in the Georgia Basin-Puget Sound region was

released in May 2002, bringing to fruition a three-year process. An important aspect of the project beyond the report itself was understanding of the processes—scientific, institutional and personal—that enable—and inhibit—the production of a binational report. This paper will review some of the lessons learned and suggest some ways to move forward.

While, during the past decade, there has been a considerable amount of indicator development including interest in both standard environmental and broader sustainability indicators, there have also been many differences between data on the two sides of the boundary and even within each country. From an extensive list of potential indicators suggested at a gathering of Georgia Basin and Puget Sound experts in 1999 that had to be reduced for various technical reasons, the Ecosystem Indicators report dealt with a small selection of six indicators driven largely by data availability.

The development of a common set of indicators that could be integrated and reported side by side faced many hurdles. These included:

- Different and often incompatible approaches to environmental monitoring
- Different institutional or governance goals, needs and responsibilities;
- Different legal frameworks on which management needs and monitoring are based;
- Different cultural contexts on both sides of the border;
- Limited capacity for a transboundary approach, especially for agencies whose mandates were constrained and subject to increasingly scarce resources.

The completion of this first report has resulted in a much better understanding of the various organizational, political and technical hurdles to be overcome to achieve ecosystem based reporting in the region. Challenging some conventional approaches and newly developed working relations across organizations have inspired those involved to continue breaking down barriers to the cooperative management of ecosystems that see no boundaries. The development of the report also sparked a stronger recognition of the value of seeing the indicators in a broader policy context, with concern for both past and future implications of environmental stresses in the face of the primary and continuing causal factors: population growth, consumption patterns and urban development.

Suggestions will be made on furthering the institutional capacity and effective working relationships to support the process. Another way forward may be to expand the scope of the suite of indicators to additional environmental and broader sustainability issues. Finally, a discussion of how to encourage informed decision making at all levels, based on this information will engage, the issues of the links between

science, policy and decision-making, and effective reporting and marketing of the information products in order to encourage behavioural change.

Session 3B: CLIMATE CHANGE (III)

Influence of Climate Change on the Productivity of Douglas Fir in the Georgia Basin

Dave Spittlehouse

BC Min. Forests

Douglas-fir occurs on about 1.35 million hectares of the Georgia Basin. Over 90% of the stands are second growth stands and they provide about 1 million m³ of timber a year. Growth of Douglas-fir is strongly related to moisture availability. Global warming is predicted to result in summers that are warmer and drier in southwestern BC. The possible effect on the productivity of coastal Douglas-fir under climate change was determined using field measurements of site index and summer water availability. Available water is the sum of the water storage capacity of the root zone and the May to July rainfall. Relationships between site index, yield, product recovery and net present value (NPV) of the wood were developed from data in the Ministry of Forests timber production and recovery analysis system. A 10 to 20% reduction in rainfall could result in a reduction in site index of 2 to 4 m, stand volume by 75 to 150 m³ ha⁻¹, and NPV of \$1000 to \$2000 ha⁻¹. Warmer and drier conditions will also increase risk of regeneration failure, and disturbance through fire and pests.

Climate Impacts on Life History Events of Southern British Columbia Sockeye Salmon (*Oncorhynchus nerka*) Populations and Options For Adaptive Management in the Face of Future Climate Change

Kim D. Hyatt

Fisheries and Oceans Canada

Populations of sockeye salmon on the southern end of their range in the eastern Pacific are considered to be especially vulnerable to effects of future climate warming. In this paper two of these stocks are examined for historic interactions among climate change, life history events and management responses to changes in fish abundance. Both model analyses and empirical observations suggest that periods of climate warming are accompanied by:

- (i.) Increases in the frequency and magnitude of adult migration delays and mortality events.
- (ii.) Delays in the timing of peak spawn and egg hatch.
- (iii.) Moderate to pronounced seasonal reductions in lake rearing habitat
- (iv.) Annual reductions in marine survival.
- (v.) Large decreases in stock productivity.

Sustainable fisheries for Barkley Sound sockeye salmon on the west coast of Vancouver Island have been maintained for more than a century in spite of high variability in total returns of adult salmon. By contrast, fisheries for Clayoquot Sound sockeye on the west coast of Vancouver Island and for Okanagan sockeye salmon in interior B.C. have all but disappeared given multidecadal trends for stock declines in which climate change is implicated. Results reported here provide a preview of potential future climate impacts on production variations of southern salmon stocks and the scope for adaptive responses by salmon, fisheries resource stakeholders and the institutions that form an important interface between them.

Simulating Coastal Responses to Climate Change: Innovative Means of Stakeholder Involvement

Larissa A. Naylor, Tim O’Riordan and Andrew Watkinson

University of East Anglia

A dynamic, interactive and locally-relevant assessment tool is being developed, as the flagship research project of the Sustaining the Coastal Zone research theme at the Tyndall Centre for Climate Change Research, UK. The coastal simulator examines the effects of different sea-level rise and adaptation scenarios on coastal habitats and communities in East Anglia. A key innovation of the simulator is to involve stakeholders throughout the model design and development process – by encouraging local citizens to help participate in shaping the future of coastal communities and habitats. Part of this research has involved a series of agenda setting workshops entitled, ‘Redesigning the Coast’ which has led to some very fruitful discussions about new forms of institutional governance in the coastal zone and innovative means of stakeholder dialogue. The series has progressed from engaging with scientists, government and non-government organisations, to the residents of Norwich and, lastly, to include 67 representatives from local parishes along the coast of East Anglia. This paper outlines the coastal simulator project and details how the ‘Redesigning the coast’ workshops have been used to improve the dialogue between scientists and stakeholders, by raising local awareness of coastal responses to climate change and helping feed local knowledge into research projects.

Explaining Climate Change in Southwestern BC: The Temperature Rising Poster Story

Bob Turner

Geological Survey of Canada

John Clague

Department of Earth Sciences, Simon Fraser University

Bill Taylor

Environment Canada

Eric Taylor

Natural Resources Canada

Nancy Grenier and Marnie Olson

Greater Vancouver Regional District

Temperature Rising is a highly successful, large format, graphics-rich poster that deals with climate change in southwestern British Columbia. The poster discusses the science of climate change, possible impacts of climate change over the next 50 years on southwestern BC, and the challenge of dealing with this issue. The target audience for the poster are students in secondary school, colleges and universities, their teachers, and the educated general public. The poster was jointly produced by Natural Resources Canada, Environment Canada, and Simon Fraser University in partnership with BC Environment Lands and Parks, Greater Vancouver Regional District, other federal departments, and non-governmental organisations. Since 2000, over 4000 posters have been distributed including 2100 via teacher workshops, and 600 to educators through direct request. Posters are available through the Geological Survey of Canada sales office (604-666-0271) and are free to educators. The poster content can be accessed on the internet at <http://www.gvrd.bc.ca/climate/index.html> and at http://adaptation.nrcan.gc.ca/posters/home-accueil_en.asp. The poster became the prototype for 6 other regional climate change posters produced by NRCAN for regions across Canada. The GVRD Education department has developed a popular climate change workshop (also on their website) based on the poster.

Session 3C—Panel : STAKEHOLDER INVOLVEMENT IN STEWARDSHIP AND PLANNING

Evolving Indigenous Approaches to Coastal Watershed Stewardship: Research and Planning Processes Initiated by the Tsleil-Waututh First Nation in Indian Arm and the Indian River Valley

Douglas Aberley

Tsleil-Waututh First Nation

The Indian River drains a small 20,000 hectare coastal watershed located just north of metropolitan Vancouver at the head of Indian Arm. The Tsleil-Waututh First Nation has utilized this watershed as a source of a wide variety of natural resources for thousands of years. Over the past 150 years the basin has been heavily exploited for

its forest, mineral and fish resources by government and corporate interests. At present, very little of the old growth forest remains, and the narrow valley is occupied by over 100 kilometers of logging roads, a 500 kV hydroelectric transmission line, a gas pipeline, and a log dump. All these developments have had outflow effects on Indian Arm, a deep fjord that remains relatively isolated from tidal flows in Burrard Inlet and the Strait of Georgia.

The Tsleil-Waututh First Nation has taken a leadership role in designing and implementing a comprehensive 'Watershed Stewardship' initiative for Indian Arm and the Indian River valley. This process has involved activities including completion of detailed biophysical mapping, negotiating a co-management agreement for Indian Arm Provincial Park, the private purchase of 400 hectares of forest lands on which eco-forestry is being practiced, restoration of wild salmon runs, and a number of related initiatives. The purpose of this presentation is to highlight the role an urban First Nation has played in putting its indigenous land and water stewardship ethic into practice.

A Public Process for Updating First Nation Disposal Practices

Brenda Maguire, Ananthan Suppiah and Robyn Weisner

First Nations' Emergency Services Society

First Nations people comprise approximately three percent of British Columbia's total population. About 56,000 First Nations people live in some 300 reserve communities, which make up 199 'Bands'. This includes remote, isolated communities along the coast, where the development of a proper system for the collection, transportation and disposal of solid wastes has been impeded due to factors such as the lack of road access, available land, trained operators & maintenance personnel, and the high cost of long-haul barge transport. The resulting solution was a patchwork of unsustainable disposal methods including open burning, dumping, and in some cases, incineration. These 'solutions' were developed in isolation of what was happening in the neighbouring communities, both aboriginal and non-aboriginal.

This paper outlines a different approach to solid waste management planning that is being encouraged by the First Nations' Emergency Services Society (FNESS), an organisation that provides essential services to First Nation communities in British Columbia. This 'big-picture' approach is based on:

- Integration of collection and transportation services to a number of such communities.
- Integration with the regional solid waste management plans.
- Community education in appropriate disposal options and waste reduction.
- Participation of an informed community in decision-making.

Our case study, demonstrating this approach, will be based on a First Nation Band located on the west coast of Vancouver Island. One of the 'reserves' is located on a small island, which has a dumpsite that has been used by the community for more than 30 years. This dumpsite is an environmental and safety concern for the band and they would like to find a solution. The community was kept informed of the work done by a consultant company during their investigation of the environmental impacts of the current dumpsite. Band members were then asked to participate in the decision-making process as a solution was developed for this dumpsite.

An International Non-governmental Organization in the Salish Sea

Ben Starkhouse

University of Washington

The Puget Sound Georgia Basin marine ecosystem of Washington and British Columbia is saturated with species bio-diversity that's richness is matched by only a handful of other regions in the world. Countless marine mammals, shellfish, invertebrates and plants have thrived in and around the nutrient rich waters of North America's second largest estuary for thousands of years. Because of this abundance of life, Native American Tribes and First Nations settled in this area and developed a lifelong bond with their surroundings. Today the health and survival of the inland sea is in jeopardy. The area's growing population and development place additional pressure on an ecosystem already struggling from years of anthropogenic pollutions intentionally and unintentionally finding their way into the marine waters of the Puget Sound and Georgia Straits. On both sides of the international border there are attempts being made to protect, manage and restore certain areas of the trans-boundary marine ecosystem. Governmental agencies and private organizations of British Columbia and Washington State have recognized the need to work together on our regions marine issues. In recent years they have strived to develop efficient and productive working relationships. The problem is, everyone trying to develop these trans-boundary relations is simultaneously working on dozens of other things. However, if there were an organization focused specifically on the area's marine issues without regard for the political boundary that divides and disconnects the continuous ecosystem, there is potential to achieve loftier goals. After all, shouldn't a marine ecosystem and marine species that know no boundaries be managed, protected and restored by an organization that also knows no boundaries?

Coastal Planning in the Strait of Georgia: Case Studies on Baynes Sound and Malaspina Inlet Complex

Joe Truscott

Ministry of Sustainable Resource Management

The British Columbia government is developing broad coastal use plans for sustainable tenuring decisions and plans designed to address specific coastal issues. This paper

describes each type of plan undertaken in the Georgia Basin: a coastal use plan for the Malaspina Inlet Complex near Powell River and a Shellfish Aquaculture Action Plan for Baynes Sound between Denman Island and Vancouver Island.

In the Malaspina Inlet Complex intense resource use conflicts involving shellfish aquaculture, recreation and tourism, fisheries and upland development have existed for several years. The province led a public consultative planning process with federal, local and First Nations government participation. The resultant plan guides the management and allocation of marine aquatic lands, including intertidal areas, in order to increase land tenure decision-making efficiency and to guide the long term sustainable use of the coastal land and resources of the plan area.

Baynes Sound has been used for shellfish culture for many years. Increased technological development of the existing industry and interest in expansion has precipitated intense conflicts with upland owners and other resource users such as fishers and recreationalists, and has raised concerns from some area residents about the potential for environmental impacts. The Baynes Sound Plan used a science-based and consultative approach to address these conflicts by determining if and where future sustainable development opportunities exist for shellfish aquaculture and provided some measures to address issues with existing operations.

Conducting Research with Junior and High School Students Using a Remotely-Operated Vehicle—A Collaborative Project Between Private and Public Agencies

Judy D'Amore

Port Townsend Marine Science Center

David Duggins

University of Washington Friday Harbor Laboratories

Robert E. Pacunski

Washington Department of Fish and Wildlife

A partnership between staff from the Port Townsend Marine Science Center, the University of Washington Friday Harbor Laboratories (FHL), Western Washington University Shannon Point Marine Center (SPMC) and Washington Department of Fish and Wildlife (WDFW) was formed to utilize existing underwater technologies to expose junior high and high school students to the science of marine biology. Scientists from PTMSC, FHL, SPMC and WDFW, in collaboration with science teachers from local school districts, developed a pilot project that would allow students to collect and analyze a variety of biological and geological data with a small remotely-operated vehicle (ROV) owned by FHL. Grant moneys obtained from a number of sources were used to establish sample sites at two rocky reef locations in San Juan County, Washington and to charter a research vessel equipped to handle the ROV. The sampling regime was designed such that data collected by the students could be used to augment reef-fish data being collected by scientists at WDFW.

Providing middle and high school students with advanced underwater technology (i.e. ROV's) for student research is a highly innovative approach to engaging students in field science investigations. In this paper we describe the processes of project development and initiation so that they might be used as a template for the development of similar programs around the country.

Session 3D: Panel DEVELOPMENT PATTERNS AND ECOSYSTEM FUNCTION— WHAT DO WE KNOW?

A Review of the Effects of Landscape Patterns on Local Bio-metrics

Marina Alberti

University of Washington, Urban Design and Planning

Streamflow Metrics for Linking Landscape Changes to the Condition of Stream Ecosystems in the Puget Sound Basin

Christopher P. Konrad

U.S. Geological Survey

The conversion of the Georgia/Puget Sound Basin landscape from forests and fields to a patchwork of residential and commercial developments linked by roads has had profound hydrologic consequences - from the hillslopes that produce runoff to the streams that receive it. The hydrologic effects of urban development have been well quantified in social terms (e.g., flooding and water supply) but not in terms that are necessarily relevant to ecological processes. Metrics used to evaluate the ecological significance of streamflow patterns must address the role of streamflow both as the primary physical medium of stream ecosystems and as an agent of disturbance. Moreover, such metrics must evaluate streamflow patterns over time-scales greater than those associated with the resiliency of lotic communities to resist changes in streamflow patterns or their recovery after a hydrologic disturbance. Three streamflow statistics were evaluated as potential metrics for assessing the landscape changes associated with urban development are translated to the biological conditions of streams. The statistics are the fraction of a year that annual mean discharge is exceeded (T_{Qmean}), the coefficient of variation of annual maximum floods (CV_{AMF}), and the fraction of time that streamflow exceeds the magnitude of a flood peak occurring twice a year on average (T_2). The statistics were related to both land use and biological conditions of streams in western Washington State and, thus, may be useful for assessing the ecological significance of landscape changes in the Georgia/Puget Sound Basin.

The Implications of Landscape Change on the Function of River Basin-scale Processes

Brian Collins

University of Washington, Earth and Space Sciences

The Fiscal Side of Protecting Fish: Can Compact Development Protect Your Community's Basins and Budgets?

Gillian Mittelstaedt

Sustainable Community Solutions

A decade of tracking dollars and development has made it clear: land-use patterns that are infrastructure-intensive place a significant drain on the fiscal resources of local, state, provincial and federal agencies. But creeping imperviousness isn't just bad for budgets; it is also the toehold that precedes major alterations to a basin's aquatic functions and integrity. This session will review recent literature on the fiscal implications of sprawling development patterns. Several case studies will be cited that illustrate the cost-savings associated with compact development—at the site, neighborhood and community scale. It will conclude with a menu of policy and planning techniques that promote compact development, with visuals and model code language to take back to your community.

Session 3E: CONTAMINANT EFFECTS ON FISH

Mechanisms of Polycyclic Aromatic Hydrocarbon Toxicity in Early Life History Stages of Fish

**John P. Incardona, Tracy K. Collier
and Nathaniel L. Scholz**

NOAA Fisheries

Urbanization contributes fossil fuel-derived polyaromatic hydrocarbons (PAHs) to aquatic and estuarine environments. In the Georgia Basin/Puget Sound region, non-point sources of PAHs are increasing. Regional monitoring studies have detected PAHs in both marine and anadromous fish species, and a common suite of morphologic defects, including edema and dorsal curvature of the body axis, have been observed in marine and freshwater fish embryos exposed to hydrocarbons in the laboratory and in the field. However, basic mechanisms of PAH toxicity in fish embryos and larvae are still poorly understood. To address this uncertainty, we designed a study to (1) identify the tissue and molecular targets of PAHs during early developmental stages, and (2) determine which individual PAH congeners (within a complex mixture) contribute to the morphological defects that have been previously reported. These studies were conducted using the zebrafish (*Danio rerio*), a leading experimental system for molecular and genetic analysis of vertebrate development. Our results indicate that:

- (1) PAHs act on specific targets in the excitatory conduction system of the developing heart.
- (2) Most of the morphological defects induced by PAHs are secondary to cardiac dysfunction.
- (3) Dibenzothiophenes and phenanthrenes are major contributors to PAH-induced developmental toxicity.

Do PCBs or PAHs Affect the Innate or Acquired Disease Resistance of Chinook Salmon to *Listonella anguillarum*?

David B. Powell and Roger C. Palm, Jr.

ProFishent Inc.

Ann Skillman

Battelle Marine Science Lab

Kathy Godtfredsen

Windward Environmental LLC

Controlled laboratory challenges with *Listonella* (*Vibrio*) *anguillarum* bacteria were used to determine the effects of dietary exposure to Aroclor® 1254 (PCBs), or to a mixture of 14 polyaromatic hydrocarbon compounds (PAHs), on the immunocompetence of juvenile chinook salmon. Salmon were fed different concentrations of PCBs or PAHs for 4 weeks. The doses used bracketed levels reported in the stomach contents of Puget Sound salmon. To examine innate immunity, half of the fish were challenged with pathogenic *L. anguillarum* and monitored for 14 days. Subsequently, the other half were vaccinated (excluding controls) and transferred to replicate challenge tanks where specific immunity was allowed to develop for 3 weeks prior to challenge. All mortalities were individually necropsied to identify the cause of death. A separate oral LD50 test that was run to measure acute toxicity revealed no mortality over 96 hours, despite doses as high as 800 mg Aroclor 1254 per kg fish. The challenge data indicated that dietary PCB or PAH exposures, even at relatively high levels, did not have a significant effect on growth, innate disease resistance, or acquired immunity to *L. anguillarum*.

Is PAH Exposure of Adult Coho Salmon Related to Abnormal Pre-spawn Mortality?

Gina M. Ylitalo, Jon Buzitis, Margaret M. Krahn, Nathaniel Scholz and Tracy K. Collier

Northwest Fisheries Science Center

Populations of wild Pacific salmon are declining, and it is accepted that various natural and anthropogenic factors have contributed to the decline of these salmon populations. Over the past three years (1999-2001), high numbers of pre-spawn adult coho salmon (*Onchorhynchus kisutch*) have been found dead in small streams in urban and developing areas of Puget Sound (see presentation by Reed et al., this conference). Other species of salmonids that spawn in these streams do not appear to be dying in appreciable numbers. Although the causes for the pre-spawn mortalities of the Puget Sound coho are not known, the deaths do not appear to be related to disease or high parasite loads. There have been anecdotal observations of neurological

symptoms (e.g., gaping, convulsions) in the affected fish. Preliminary analyses by the National Marine Fisheries Service, Northwest Fisheries Science Center, indicate that the symptomatic pre-spawn coho had significantly elevated concentrations of metabolites of polycyclic aromatic hydrocarbons (PAH) in their bile compared to levels in non-symptomatic pre-spawning coho. Further sampling and analysis during the 2002 spawning season is being conducted to evaluate the hypothesis that PAH exposure may contribute to the observed abnormal mortality events, and we will present and discuss our results.

Further Survey Results on Xenoestrogen Exposure of Benthic Fish in Puget Sound

Daniel P. Lomax and Lyndal L. Johnson

NOAA-National Marine Fisheries Service

James E. West and Sandra M. O'Neill

Washington State Department of Fish and Wildlife

Tracy K. Collier

NOAA-National Marine Fisheries Service

Vitellogenin (Vtg), a yolk protein produced in the liver of oviparous animals in response to estrogens, normally occurs only in sexually mature females with developing eggs. However, males can synthesize Vtg when exposed to exogenous estradiol or to substances that mimic estrogens. Thus, the abnormal production of Vtg in male animals can be used as a biomarker for exposure to estrogenic substances. Beginning in 1997, as part of the Puget Sound Ambient Monitoring Project (PSAMP), we have collected plasma from adult male English sole from numerous urban embayments in Puget Sound to analyze for the presence of Vtg utilizing a quantitative ELISA for this species. Results from the first 3 years (1997-1999) of the project revealed the presence of significant levels of Vtg in fish from several urban sites. Although no direct correlation was established with contaminant levels in bottom sediments, the results did suggest that the highest Vtg concentrations and greatest percentage of animals affected were from sites near combined sewage overflows (CSOs). Sampling efforts between 2000-2002 included the addition of new sites and also continued follow-up survey at several 'sites of concern' to better ascertain the spatial and temporal nature of the problem. These new results should enable us determine the extent to which xenoestrogens maybe be affecting the health of marine fish in Puget Sound.

The Exposure-Dose-Response Triad in the Georgia Basin: Synoptic Measures of External Chemical Exposure, Internal Chemical Dose, and Associated Biological Responses

Michael H. Salazar and Sandra M. Salazar

Applied Biomonitoring

Bioaccumulation is the ultimate link between environment and organism, and a necessary element for evaluating marine environmental quality and ecosystem health. Furthermore, monitoring and assessment programs need to establish links between water, sediment, and tissue

chemistry and with effects on organisms, to provide meaningful results that can be used as the scientific basis for regulatory decisions on toxic loadings. The exposure-dose-response triad emphasizes the measurement of tissue chemistry and associated biological responses, incorporates components of laboratory testing and field monitoring, and adds elements of controlled field testing. This approach is consistent with ecological risk assessment paradigms that emphasize characterizing exposure and effects. Traditional approaches, such as the sediment quality triad, successfully identify whether contaminants are entering the system and if there is a measurable response but do not directly address whether or not contaminants are biologically available and whether these contaminants are causing the response. There is a disconnect between exposure, dose, and response in many Georgia Basin and Puget Sound monitoring programs designed to quantify the status and trends in ambient conditions. The purpose of this paper is to demonstrate a different approach for establishing those links by using bivalve monitoring and the tissue residue effects paradigm.

Improving Estimates of Contaminant Exposure for Mobile Organisms: An Assessment of Area-weighted Home Range Exposure Estimates Applied to the Relationship Between Sediment Chemistry and Liver Lesions in English Sole

Jeffrey H. Stern

King County Department of Natural Resources and Parks

Dan P. Hennessy and Clay R. Patmont

Anchor Environmental

Liver lesions in English sole (*Pleuronectes vetulus*) have been identified as biomarkers for exposure to polycyclic aromatic hydrocarbons (PAHS). Federal researchers have been investigating the correlation between PAHS and the prevalence of liver lesions in these fish from sites along the west coast, including Puget Sound, and proposing the relationship be used to develop sediment quality benchmarks. Appropriate characterization of exposure of these mobile organisms to PAHs is essential to developing such a relationship. Areal-weighted home range PAH exposure estimates for English sole collected in Puget Sound were developed and compared with the existing data. Spatially and temporally related chemistry and lesion data from urban and background areas were compiled for areas with enough sediment data to quantify spatial variability. Areal-weighted average PAH concentrations were calculated using Theissen polygons. Exposure estimates for urban embayments were 2 to 5 times greater than those estimated using only the synoptic trawl line samples. Proposed sediment quality benchmarks derived by non-linear "hockey-stick" regression were 2 to 3 times greater using the areal-weighted home range exposure estimates. Results verified the relationship between sediment chemistry and liver lesions but the difference in the results using a more robust statistical approach suggest an improved method for calculating exposure estimates for mobile organisms. Such exposure estimates are needed

for risk assessments and biological opinions needed by decision-makers to make resource decisions.

Session 3F: NEARSHORE HABITAT INVENTORIES

Rapid Shoreline Inventory—Inventorying Shoreline Resources and Interpreting Shoreline Health

Jacques White, Phil Bloch, Tom Dean

People For Puget Sound

The Rapid Shoreline Inventory (RSI) is a project created by People for Puget Sound with the assistance of regional experts that links the information needs of resource managers and restoration practitioners to well-trained volunteer stewards who collect detailed data about marine and estuarine shorelines. The RSI consists of 6 key components:

- (1) Identification of resource information needs.
- (2) Permission to access shorelines from property owners.
- (3) Careful classroom and field training of volunteers.
- (4) A rapid inventory of contiguous 150 ft. sections of Puget Sound shoreline.
- (5) Creation and maintenance of the associated GIS database and web site.
- (6) Analysis of spatial data for conservation and restoration opportunities.

Rapid Shoreline Inventory data is valuable both for describing the resources found on the shoreline and for developing predictive models of shoreline health. People For Puget Sound has developed a series of models that use RSI data to describe shoreline health and to identify restoration and conservation opportunities. In addition to targeting restoration and conservation actions, RSI data can be used to support several coastal and estuarine management activities including identification of marine protected areas, regional and site land use planning, research, monitoring and oil spill response.

Bainbridge Island Nearshore Structure Inventory

Peter Namtvedt Best

City of Bainbridge Island

The City of Bainbridge Island conducted a detailed inventory of nearshore structural modifications (e.g. bulkheads, docks, groins) and select natural shoreline features (e.g. overhanging riparian vegetation) during the Summer of 2001. The objective of the inventory was to support the Bainbridge Island Nearshore Assessment and the City's Shoreline Master Program update by developing a baseline of existing structural modifications, mapping a detailed regulatory shoreline (ordinary high water mark), and groundtruthing aspects of the Washington

State ShoreZone Inventory (WDNR 2001). Using GPS technology and recent Washington Department of Ecology aerial photography, the City inventoried approximately 48.5 miles of shoreline by foot, kayak, and boat. Detailed attribute information compiled into a GIS database provides both a baseline inventory as well as a research database capable of supporting both land use and natural resource inquiries. The methodology and lessons learned provide a relatively cost-effective model for other jurisdictions and researchers in Washington State and could be complementary to other inventory protocols. Results demonstrate significant discrepancies between structural modification and overhanging riparian vegetation measurements with the Washington State ShoreZone Inventory estimates at a landscape-scale.

Bainbridge Island Nearshore Characterization and Assessment

Amy B. Borde and Gregory D. Williams

Battelle Marine Sciences Laboratory

Peter Namtvedt Best

City of Bainbridge Island

Ronald M. Thom and Nathan R. Evans

Battelle Marine Sciences Laboratory

The City of Bainbridge Island is conducting a seminal nearshore characterization and assessment project funded through the Salmon Recovery Funding Board. The primary objective of this effort is to provide baseline data upon which to develop and implement nearshore management strategies (including restoration and preservation) and measure management success. A science-based conceptual framework was used to characterize the status of shoreline ecological functions based upon systematic evaluations of shoreline modifications, controlling factors, habitat structure, and habitat processes. Approximately 48.5 miles of shoreline was broken down into nine management units (based on drift cell knowledge) and each unit was analyzed by reach (based on the WADNR ShoreZone Inventory). Digital data, including the Bainbridge Island Nearshore Structure Inventory, was quantified using GIS which was in turn used to conduct a qualitative (3-tier) assessment using defensible, systematic matrices. The qualified measures were based on quantified parameters derived from the literature, current and historical shoreline photos, and expert opinion. This information was synthesized to determine human impacts, locating critical areas for protection or restoration, and identifying nearshore ecosystems most at risk to cumulative impacts. Based on readily available or easily collectable data, this approach could provide a useful framework for similar assessments in Puget Sound.

The Sensitive Ecosystems Inventory of East Vancouver Island and Gulf Islands: Latest Evaluations of Status

P. Marlene Caskey

Ministry of Water Land and Air Protection

Judith Cullington

Judith Cullington & Associates

The Sensitive Ecosystems Inventory of East Vancouver Island and Gulf Islands (SEI) identified and mapped rare and fragile ('sensitive') ecosystems using aerial photography and selected field checks. Results of this SEI (1993-1997) showed that only 7.9% of the study area remained in a relatively natural state. Since publication of the maps and data, a variety of outreach tools have been used to promote the SEI. Development pressures continue, so the principal agencies (Canadian Wildlife Service, Ministry of Water, Land and Air Protection and Ministry of Sustainable Resource Management) have been assessing the effectiveness of the SEI products and outreach program in minimizing the rate of ecosystem loss. Three projects will be discussed:

- Audit of Selected Polygons of the SEI of East Vancouver Island and Gulf Islands, 1999-2001
- SEI Outreach Evaluation, 2002
- Field checking of additional polygons, 2002

In addition, satellite imagery is being assessed for accuracy/applicability, and 2002 ortho-photography will be used for a review of all the original polygons. This conference paper will examine the effectiveness of the SEI approach, the implications of vanishing habitats, and the tools that have been the most effective in the protection of sensitive ecosystems.

A Habitat Assessment Approach for Identifying Priority Nearshore Estuarine Conservation and Restoration Areas

Paul Schlenger, John Small, Peter Hummel, Elizabeth Appy and Tom Schadt

Anchor Environmental

A nearshore habitat inventory and assessment was conducted in South Puget Sound, Washington to evaluate habitat function in order to identify priority areas for conservation and restoration that will support the recovery of the region's salmonids. The study area encompassed Hammersley Inlet and Oakland Bay in Mason County, WA. The Squaxin Island Tribe and Taylor United Shellfish sponsored the project, which was funded primarily by the Salmon Recovery Funding Board.

This comprehensive assessment provides the foundation for future site-specific nearshore salmon recovery projects in study area. GIS-based models of habitat function were developed to process new and existing habitat data and evaluate the levels of existing habitat function. The models focus on key ecological functions that estuarine and

nearshore marine habitats provide to juvenile salmonids, including: availability of prey resources, predator refuge, physiological refuge for acclimation to marine environment, and migration corridors. A scoring system was developed to characterize the relative contribution or impact of each habitat type and shoreline modification (e.g., bulkheads, docks, etc.) to each ecological function. The identification of priority areas for conservation and restoration incorporated the output of the habitat function model, as well as landscape ecology principles and best professional judgment considerations of ecosystem processes.

Changes to the Shoreline of Fidalgo Bay and Eastern Guemes Channel Since 1891: The Value of a GIS Approach

S. Wyllie-Echeverria

School of Marine Affairs

A. Bailey

TerraLogic GIS

B. Williams

Washington State Department of Fish and Wildlife

While it is widely recognized that efforts to industrialize the shoreline of the Georgia Basin and Puget Sound resulted in the loss of intertidal and subtidal habitat, the amount of this loss is rarely quantified. In this case study research project we examined historical changes to nearshore aquatic habitats in Fidalgo Bay and Eastern Guemes Channel since 1891. We found that while some regions within the study site remained relatively unchanged, other regions were highly modified. For example, the amount of fill along the northwest shoreline of Fidalgo Bay (~38 ha) equals 16.5% loss of intertidal and subtidal habitat since 1891 while only 2.3% of this habitat has been lost in the rest of Fidalgo Bay within the same time frame. Comprehensive data layer analysis in a GIS format allowed us to:

- (1) quantify changes to the shoreline and bathymetry since 1891.
- (2) visualize these changes overlain on aerial photographs.
- (3) estimate human impacts to intertidal and subtidal vegetation and forage fish spawning areas.

We will discuss the implications of our study as a guide for the restoration of Fidalgo Bay and Eastern Channel and as a template for other studies in the industrialized regions of Puget Sound Basin.

Session 4A—Panel CONNECTING SCIENCE, POLICY AND DECISIONS IN INDICATOR DEVELOPMENT AND REPORTING

Discussion of indicator development, policy, social marketing as well as issues raised in session 3A. An open discussion will take place after brief opening statements.

- **Risa Smith**, Environment Canada
- **Chris Parsons**, Washington Department of Community, Trade and Economic Development
- **Archie Riddell**, British Columbia Ministry of Sustainable Resource Management
- **Nola Kate Seymoar**, International Centre for Sustainable Cities
- **Lee Hatcher**, AtKisson, Inc
- **Noreen King**, Belo Marketing Solutions

Session 4B: TRANSBOUNDARY AIR QUALITY (I)

Georgia Basin/Puget Sound International Airshed Strategy (IAS)

Martin Mullan

Environment Canada

Nancy Helm

U. S. Environmental Protection Agency

Characterization of the Georgia Basin/Puget Sound Airshed

Bruce Thomson

Environment Canada

Representatives from all levels of government, from First Nations and Tribes have started to develop a comprehensive international air quality management plan for the Pacific Northwest. One of the products of these meetings is a Statement of Intent that describes activities deemed to be of high priority for international air quality planning. The Characterization of the Georgia Basin/Puget Sound Airshed is one of these activities. The focus of this "characterization" is ground level ozone, fine particulate matter and visibility. These three components of the air quality picture fit very well with the immediate policy needs within the airshed. Policies being dealt with include the Regional Haze Rule, implementation of new ambient air quality standards for fine particulate matter and ground level ozone (Canada Wide Standards), the Ozone Annex (2004) and a possible PM Annex (2005).

The Characterization of the Georgia Basin/Puget Sound Airshed will provide a clear and comprehensive analysis of the past and present air quality conditions within the Georgia Basin/Puget Sound Air Basin and clearly identify the impacts on ambient air quality conditions within the Basin resulting from policy and planning strategies and natural processes. The study will be completed in September 2003. This paper reports on the current progress of the study and identifies future direction.

An Economic Analysis of Air Pollution Policies in the Georgia Basin-Puget Sound Transboundary Region

Carmen Hranac

University of Washington, Seattle

Since the late 1980s, there's been a growing realization that the Pacific Northwest is a transboundary ecosystem. While humans have created two countries, the region has remained one interdependent ecosystem. As such, there is a need for international cooperation in order to protect the region as a whole. To this end, the Environmental Protection Agency (EPA) and Environment Canada (EC) have signed a Statement of Cooperation on the Georgia Basin and Puget Sound Ecosystem; this statement is to be the precursor to an international airshed strategy. There is a need for an analysis of potential policies for pollutant reduction; I intend to provide this using both an econometric and a cost-benefit analysis.

It has been determined that the specific pollutants in question – SO_x, NO_x, VO_x, and CO – create varied and numerous effects on human mortality and morbidity, ranging from increased lung cancer incidence to harsher asthmatic attacks. Valuation studies have also determined effects on tourism, forest productivity, and ecosystem viability as a result of air pollution. These effects shall be monetized and input as the benefits of a pollution reduction policy. Costs shall include operating, regulatory, and enforcement issues of the relevant parties. Costs and benefits shall be calculated for three different policy actions: tradable permits, regulations, and conservation efforts. We believe that a combination of tradable permits and conservation will be the most cost-effective.

The second component is one of political economy; namely addressing the question of why society has allowed significant reductions in efficiency from air pollution. An econometric analysis of this specific region shall show the spillover effects of any open access good, providing the groundwork for a formal discussion of the problem.

Long-term Rain Chemistry Monitoring on Vancouver Island

Warren McCormick

BC Ministry of Water, Land and Air Protection

Rain Chemistry monitoring (Acid Rain) has been carried out on Vancouver Island at various sites dating back to the mid-1980's. Presented here is data from three long term sites (Victoria, Nanaimo and Port Hardy) and one more recent site (Campbell River). Spatial patterns show a definite north-south trend with Port Hardy showing consistent background results. Temporal trends show a definite improvement at Victoria but not at any other sites. Sulphate and Nitrate concentrations and deposition results are below criteria levels but show some opposing temporal trends. The overall conclusion is that the rain chemistry over the entire Georgia Basin is affected by human activities.

Georgia Basin/Puget Sound Air Quality Modelling

Colin di Cenzo

Environment Canada

“What is the significance of Canada/United States transboundary air pollution on ambient air quality over the Georgia Basin/Puget Sound airshed?” and “What are the impacts of the forecast changes in pollutant emissions?”

The answers to these two questions are of interest to both policy-makers and scientists. The region is subject to continuing population growth that requires continued vigilance and action to maintain and improve air quality. Medical health officials have strongly encouraged air quality agencies to focus on ambient air quality conditions as most relevant to human exposure. The complex terrain and marine environment pose unique challenges for scientists.

In May 2000, a number of universities and federal, provincial/state, and local agencies (the consortium) met and agreed to a number of common standards and protocols for studying and numerically simulating air quality over the Pacific Northwest.

The consortium adopted a common mapping projection and file format, developed a joint emissions inventory, and suggested the application of the Community Mesoscale Air Quality (CMAQ) model to the airshed. In August 2001 the group participated in an extensive air quality field study (known as Pacific2001) across the Georgia Basin/Puget Sound airshed. Information gained from the study is critical to the validation of the CMAQ model for use over the Pacific Northwest.

In the last year, Environment Canada and its partners in the consortium have taken steps towards both validating CMAQ and in using CMAQ to answer the “two questions”. This presentation will provide preliminary information on the success these endeavours.

Session 4C: DEMERSAL AND PELAGIC FISH—STATUS AND DISTRIBUTION

A Comparison of the Populations of Pelagic Fishes in Puget Sound and the Strait of Georgia

R.J. Beamish, R. Sweeting, C. M. Neville and G. A. McFarlane

Fisheries and Oceans Canada

The Strait of Georgia and Puget Sound are frequently described as the Georgia Basin, implying that there is continuity between the two ecosystems. We compare the

results of 7 years of trawl studies to show that while there is similarity of species between the two areas, there are important differences in abundances and behaviour of key species such as Pacific hake, Pacific herring, spiny dogfish and Pacific salmon. These differences indicate that an exchange of species between the two areas probably is minimal.

Fish Without Borders: Trends in the Status and Distribution of Groundfish in the Transboundary Waters of Washington and British Columbia

Wayne A. Palsson, James Beam, Sue Hoffmann, and Paul Clarke

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Between 1997 and 2001, the Washington Department of Fish and Wildlife conducted a series of bottom trawl surveys in the southern Strait of Georgia, San Juan Islands, and eastern Strait of Juan de Fuca. The survey goal was to estimate the abundance of demersal fishes and macroinvertebrates in the Washington and adjacent British Columbian portions of the transboundary waters. The spring-time surveys consisted of trawling at stations that were stratified by depth and selected on a systematic or random basis. At each station, a research bottom trawl fitted with a fine-mesh codend liner was towed from a chartered fishing vessel for approximately 10 minutes at a speed of 1.5 to 2 knots. In all, 170 trawls were conducted in Washington portions of the survey area, and 119 stations were occupied in the British Columbian portion.

In 1997 and 2000, extensive and synoptic surveys of the Washington and British Columbian Straits of Georgia and Juan de Fuca revealed that fish biomass was roughly distributed between the two areas in proportion to the area surveyed. However, individual species were not proportionately distributed. Species with affinities to shallow and unconsolidated sand and mud substrates were relatively more abundant in the Washington survey area where these habitats were more frequent. Species frequenting harder substrates were correspondingly more common in the British Columbian and San Juan regions where these habitats were more common. Groundfish populations increased in the Washington Strait of Georgia from 11,000 mt in 1997 to 18,000 mt in 2001. A long-term declining trend in total fish abundance was evident in the Washington Strait of Juan de Fuca.

Several distinct patterns in transboundary distributions were observed that have implications for coordinated fisheries management between the United States and Canada. In the Strait of Georgia, the deep Malaspina Trough confines shallow-water species to the rim around the basin. These species are less likely to be encountered by trans-border fisheries. Deep-water species, however, were distributed along the international border making them vulnerable to

fisheries on either side of the border. The banks and troughs of the eastern Strait of Juan de Fuca presented a different pattern of species distributions. Shallow and deep-water species were distributed on either side of the international boundary making them both likely to be encountered by transboundary fisheries.

Potential Impacts of Infectious Diseases to Populations of Pacific Herring in Puget Sound

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NE Elder and JR Winton

US Geological Survey

Several highly virulent, endemic pathogens are currently maintained in populations of Puget Sound herring. Among the metapopulation of herring in Puget Sound, incidence of the protistan parasite *Ichthyophonus* is age dependent, increasing from 12% among juveniles to 55% among under-represented, 6+yr cohorts. Among juvenile cohorts, viral hemorrhagic septicemia virus (Genotype I) is maintained in low prevalences, and nearly all individuals are infected with low levels of erythrocytic necrosis virus. Although the epidemiological course of infection is different for each pathogen, laboratory studies indicate that application of nominal stressors to wild herring can elicit overt diseases, resulting in decreased fitness and/or mortality. As a result, we contend that infectious disease should not be dismissed as a major constraint limiting age structure and survival of Pacific herring populations in the region.

Status Report Census of Lingcod Nesting Activity in the Edmonds Underwater Park

Kirby W. Johnson

Snohomish County Marine Resource Advisory Commission

Progress of the ongoing effort to document lingcod nest sites in the Edmonds Underwater Park is presented. The census is done by a team of volunteer divers to measure reproduction of the fish as a general indicator of the overall health of the site. The Edmonds Underwater Park was one of the first underwater parks and is arguably one of the most popular sites for scuba diving on the North Pacific coast.

Regular visitors are aware of remarkable increases in the quantity and variety of marine life in the park over the past decades. Habitat is entirely artificial is somewhat isolated from natural lingcod habitat. The park fits most definitions of a Marine Protected Area (MPA), and predates the coining of the name. It has been a marine sanctuary since 1970. Survey methods and procedures presented at the 2001 Research Conference are briefly reviewed and survey results updated. The park typically provides more than 60 nest sites per season. Seven years of survey results will be discussed. Among the continuing observations is strong evidence of repeat usage of specific sites and repeat use of a

site by individual guard fish. The effort is a statement about stewardship in action and the value of volunteer teams.

Individual Identification and Population Parameter Estimates within Puget Sound and Georgia Basin Six-gill Sharks (*Hexanchus griseus*)

Shawn Larson and Jeff Christiansen

The Seattle Aquarium

Six-gill sharks (*Hexanchus griseus*) are known to occur in Puget Sound, and have been sighted by divers and fishermen alike over the years, but surprisingly little is known about many aspects of their biology and life history. Specifically, there is little information about six-gill population structure, home ranges, breeding patterns and phylogenetic relationships with other adjacent six-gill populations (Coastal and Georgia basin). The Seattle Aquarium is attempting to answer some of these natural history questions through individual identification and movement patterns via tagging efforts and genetic analysis via tissue sampling and hypervariable microsatellite nuclear markers. Sharks are tagged for individual identification and movement patterns opportunistically by luring to a baiting station at the aquarium. Genetic samples are collected from live sharks during tagging operations (pole spear biopsy) and from dead sharks (by catch or beach cast). Here we present both tagging and genetic data that has given us some insight into individual movement patterns and genetic diversity estimates and relatedness among Puget Sound and Georgia basin six-gill sharks.

Possible Differences in Copper Rockfish Reproduction at Maternal Length and Age

Dan Cooper

University of Washington

Copper rockfish, *Sebastes caurinus*, populations have declined throughout Puget Sound. In addition, the length structure of the population has also changed, as large fish have become less frequent. Marine Protected Areas (MPAs) are promoted to increase population fecundity by increasing both fish abundance and the percentage of larger fish. Studies suggest reproductive differences other than number of eggs exist between large and small *Sebastes* females. The objectives of this study are to:

- (1) Determine if copper rockfish fecundity decreases from unfertilized eggs to embryos.
- (2) If so, determine if fecundity percent decrease is the same for smaller and larger fish.
- (3) Determine if maternal size or age and date of parturition are correlated.

Fecundity relationships for fish with unfertilized eggs and gestating embryos were compared. No significant difference was detected. The ratio of larvae produced by larger: smaller females likely does not differ from the ratio of eggs produced by larger: smaller females. Spawning date was estimated from embryo developmental stage. Older fish had an earlier mean date of parturition than younger fish.

Populations without older age classes may have an altered parturition period, which could change recruitment or recruitment variance.

Session 4D: ECOSYSTEM-BASED POLICY AND PLANNING

Creating an Integrated Vision for Transboundary Sustainability Using a Georgia Basin–Puget Sound Simulation Tool

Dave Biggs

Envision Sustainability Tools

Roger Anderson

Battelle Pacific Northwest National Laboratory

As part of the Georgia Basin Futures Project, a computer simulation game- Georgia Basin QUEST - has been developed to assist stakeholders to visualize future conditions that may result from choices they make today. The simulation embodies expert understanding of how complex ecological, social and economic systems work. It is proving to be a valuable tool to involve a wide variety of individuals and groups in the pursuit of sustainability. Results achieved to date are summarized in this paper.

Because sustainable development of the region is inevitably affected by activities on both sides of the border, and particularly by those actions that have a transboundary consequence, there is a clear need to consider sustainability from a comprehensive geographic perspective. Stakeholders on both sides of the border are concerned about urbanization, trade and economic development, natural resources management, and a host of other issues. There is presently no effective mechanism to allow both Puget Sound and Georgia Basin stakeholders to identify common concerns or areas of consensus that can be developed into sustainability strategies. Thus we propose the development of a common, transboundary vision of a sustainable future for the entire region by extending the Georgia Basin simulation tool to encompass the watersheds and urbanizing areas of Puget Sound. This paper describes a process to accomplish that objective and invites the participation of interested institutions.

Regional Conservation Planning Data Needs

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People For Puget Sound

Jeff Ardron

Living Oceans Society

Zach Ferdaña

The Nature Conservancy of Washington

Peter Etnoyer

Conservation organizations and resource managers have begun using regional, national, and even international conservation planning as a tool to develop strategic plans for conservation of ecosystems so that resources can

be efficiently and effectively protected. This approach is predicated on the idea that sufficient information is available and can be interpreted appropriately to make informed decisions.

However at all scales of analysis various challenges are encountered as we attempt to plan for ecosystem conservation. These challenges include: the lack of data availability to planners; inappropriate or varying data resolutions; questionable data quality and reliability; inadequate or inappropriate data information (metadata); and varying or inadequate data collection or management standards (protocols).

We will examine several regional conservation planning efforts and examine lessons learned regarding the current state of data collection and management. Analysis of existing projects will also examine the reliability of analytical outputs given data uncertainty. In particular, we will examine impacts of incomplete information on the results of conservation planning efforts.

Biodiversity Conservation Strategy for the Greater Vancouver Region

Susan Haid

Greater Vancouver Regional District

Pamela Zevit

Ministry of Water, Land and Air Protection

Ken Brock

Environment Canada

In 1999, representatives from Environment Canada, the Province of B.C. and the Greater Vancouver Regional District formed a partnership to renew efforts to coordinate the management of habitat in the Greater Vancouver Region with the objective of conserving biodiversity. Increasingly, managing for biodiversity is recognized to provide multiple and synergistic environmental, economic and social benefits. It is an important characteristic of sustainability. The Biodiversity Conservation Strategy for the Greater Vancouver Region pilot project emerged through the Georgia Basin Ecosystem Initiative. Coordination with stewardship, municipal and academic initiatives is continuing to develop. This project has application to other regions within the Georgia Basin while advancing federal, provincial, regional and local biodiversity goals.

Objectives include:

- Assessing and communicating the status of ecologically significant areas
- Analysing key issues and initiatives linked to biodiversity conservation
- Developing a coordinated strategy to advance biodiversity conservation in the region.

Project partners will highlight the results of work in-progress including:

- A habitat assessment using GIS mapping, satellite imagery, and indicator species identifying

reservoirs, corridors, sensitive areas and species

- An analysis of existing policies, tools and practices affecting biodiversity conservation in the region
- Case studies evaluating social, economic and environmental benefits (e.g. nature's services) and costs of conserving biodiversity.
- Priorities and directions of the Regional Biodiversity Strategy.

The project's core planning and technical partners are Environment Canada (Canadian Wildlife Service), BC Ministry of Water, Land and Air Protection, the Greater Vancouver Regional District and the Burrard Inlet Environmental Action Program/ Fraser River Estuary Management Program. Other contributors include: GVRD municipalities, Ducks Unlimited, Simon Fraser University (Resource and Environmental Management), Douglas College Institute of Urban Ecology, Langley Environmental Partners Society.

The Northwest Straits Initiative and Conservation in Puget Sound: A Bioregionalist Analysis

Sean Harrington

The recent history of the area of Northern Puget Sound and the Strait of Juan de Fuca known as the Northwest Straits has been one of successive attempts to arrive at a conservation solution that is appropriate and workable for the interests of conservation of marine resources and of local human communities. The Northwest Straits Marine Conservation Initiative has the potential to satisfy both of these interests, and to do so in a way that creates a "bioregional" governance structure, in which the larger scale ecosystem is managed cooperatively from the bottom up.

This thesis sought to examine primarily the question of whether the Northwest Straits Initiative is in fact bioregional in form and method of operation. This was done through the establishment of evaluative criteria derived through discussion of the theoretical principles seen as constituting bioregionalism. Additionally, the place of the Northwest Straits Marine Conservation Initiative within the context of Washington State governance structures was examined.

The conclusion was reached that the Northwest Straits Marine Conservation Initiative is both bioregional in form and method of action, and is furthermore emblematic of a general shift in attitudes toward more cooperative forms of governance in Washington State.

Ecosystem-based Management as Part of a Marine Environmental Quality (MEQ) Approach in the Central Coast, British Columbia, Canada.

Glen Jamieson, Brenda Bauer and Herb Vandermeulen
Fisheries and Oceans Canada

In 2002, Fisheries and Oceans Canada (DFO) began to apply the ecosystem-based management approach developed at a national DFO workshop in 2001. Efforts have begun to determine from broader conceptual environmental objectives appropriate regionally-relevant operational, or MEQ, objectives, with associated indicators and reference points, that will be used in oceans management. From the broad conceptual objectives of conservation of species and habitat, we are defining MEQ objectives specific to BC coastal areas relating to biodiversity, productivity, and the physical and chemical properties of the ecosystem. Under each of these, further nested components were defined, utilising an 'unpacking' process that links the conceptual objectives to those suitable for operational management. For each nested component, a suite of biological properties or characteristics is considered that further describes the objective. Example indicators and reference points were also considered by operational objective, i.e. from the bottom up.

Although this effort is being implemented first in British Columbia on the Central Coast, we believe our experiences and the approach that we are advancing is also relevant to the Strait of Georgia and Puget Sound. We describe our progress to date, including our initial action plan and recommendations for further research, to further the implementation of ecosystem-based management.

Is Environmental Security a Useful Framework to Address Environmental and Sustainability Issues in Puget Sound and Georgia Basin?

Ann Lesperance, Kathleen Judd, Nancy Peterson and Barbara Reichmuth

Pacific Northwest National Laboratory

Environmental security can be defined as the relative safety from political, economic and social upheaval as a result of environmental change, be it slow or rapid, both within nations and across national borders. Internationally, environmental issues have direct links to security, as evidenced in the Middle East water disputes. In the PSGB this encompasses but is not limited to port security, energy disputes, fishing rights, water and air quality, and sustainability. The question is, could such environmental or natural resource problems pose a serious threat to regional cooperation or stability in the PSGB? The PSGB is faced with population growth, increasing economic and natural resource interdependence, and other issues that can contribute to political stress across national boundaries. Through a literature review and interviews with key regional stakeholders, this paper examines the current regional context and defines scenarios under which different

environmental issues could lead to serious political stresses in the region. This discussion is expected to provide a useful focus for future collaboration and integration in the PSGB.

Session 4E: PCBs IN GEORGIA BASIN/ PUGET SOUND ECOSYSTEMS

Overview of Results from a Workshop Addressing PCBs in Puget Sound and Georgia Basin Ecosystems

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Environmental Protection Agency

Tracy Collier

National Oceanic and Atmospheric Administration

Karen Kinnee

BC Research, Inc.

April Markiewicz

Western Washington University

From September 16 to 19, 2002, the Pacific Northwest Society of Environmental Toxicology and Chemistry sponsored a workshop at the University of Washington, Friday Harbor Marine Laboratory, on San Juan Island, WA. Over 50 scientists (including managers) gathered to discuss how PCBs enter and move through marine food webs in Puget Sound and the Georgia Basin. One of the main goals accomplished was to provide a forum to encourage collaborations between disciplines as well as between U.S. and Canadian counterparts. Early sessions (management issues, modeling, sources and inputs, trophic linkages to and from invertebrates, fish, and marine mammals, human health issues, and analytical methodology) laid the foundations for workgroup discussions.

The three workgroups (abiotic fate, lower trophic food web, upper trophic food web) described the state of knowledge and linkages with each other group, identifying lessons learned and critical data gaps. The major workshop findings will be presented in this session.

Modeling PCBs: Lessons Learned from Large Systems

Frank Gobas

Simon Fraser University

Marine ecosystems are complex and many researchers work on only limited niches. Models help to create pictures of the larger process. In Puget Sound and Georgia Basin (PS/GB) key questions are: Why such high levels of PCBs in Orcas? Where are the PCBs coming from? What can we do to start reducing the levels? Models can help answer these questions. For example, measured PCB concentration data in biota are generally within a factor of 2.5 of model predictions.

Mass balance models developed elsewhere (e.g., Kittimat Arm, Burrard Inlet, Great Lakes and tributaries) provide a series of lessons learned that can be applied to PS/GB.

These include:

1. Start simple and recognize the tradeoffs with complexity (model input requirements need not be large).
2. Recognize disequilibrium (imbalances “force” chemicals through the benthic foodweb).
3. Understand the role of organic carbon mineralization.
4. Model at the system and organism level.

With respect to PCBs:

1. PCB toxicity to vertebrates is mostly AhReceptor-mediated (producing dioxin-like effects).
2. Measure concentrations of PCBs in tissues or diet (to link exposure with effects).
3. Know critical residue values.
4. Understand the management goals.

An important question for GB/PS is how to evaluate non-resident species?

Workshop on PCBs in Puget Sound and Georgia Basin Ecosystems: Recommendations from the Abiotic Fate Workgroup

Staci L. Simonich

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During the Pacific Northwest Society of Environmental Toxicology and Chemistry’s September 2002 sponsored workshop on PCBs in Puget Sound and Georgia Basin Ecosystems, a subgroup of scientists met to develop recommendations for understanding the abiotic fate of PCBs in the ecosystems. These recommendations include the development of a fugacity-based multimedia mass balance model for the larger, combined ecosystem that would consist of three interconnected models, each being similar to the equilibrium criterion (EQC) model, that represent Georgia Basin, Puget Sound and the Strait of Juan de Fuca. Some of the key input parameters to the model would include the net flux of PCBs into the three basins from key tributaries, the atmosphere, aquatic biota, and the Pacific Ocean. In addition, data on the partitioning of PCBs between the dissolved and particulate phases in the water column and the sediment would be required. The model would be used to predict water column concentrations in each of the three basins and to estimate PCB exposure concentrations to aquatic organisms.

A Model for Transfer of PCBs Among Plants, Invertebrates, and Lower Vertebrates of the Puget Sound/Georgia Basin Ecosystem

James E. West and Sandra M. O’Neill

Washington Department of Fish and Wildlife

We present a graphic conceptual model developed during the September, 2002 workshop entitled “PCBs in the Foodweb”, which describes major trophic pathways in the Puget Sound/ Georgia Basin (PS/GB) marine

ecosystem, through which PCBs might bioaccumulate or biomagnify. This Lower Trophic Level submodel identifies potential pathways among plants, invertebrates, and lower vertebrates, and comprises three modules:

1. A graphic image of the lower trophic levels food web (LTLFW Module) illustrating major ecological groups in the PS/GB ecosystem, and their trophic connections (“who eats whom”).
2. A text outline providing explanations of groupings and suggestions for indicator or representative species.
3. A spreadsheet that will apply what we think are the dominant uptake (e.g., gill exchange versus diet) and elimination pathways for each ecological group.

The Lower Trophic Submodel will be linked with two other submodels developed during the PCB workshop, one dealing with loadings and abiotic transfer mechanisms, and the other with PCB pathways among higher trophic levels (birds, marine mammals, and humans).

PCB Accumulation in Marine and Anadromous Fishes of the Puget Sound and Strait of Georgia

Sandra M. O’Neill and James West

Washington State Department of Fish and Wildlife

PCB concentration was measured in edible muscle tissue of adult English sole (*Pleuronectes vetulus*), demersal rockfish (*Sebastes spp.*), chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon and whole body concentrations of Pacific herring (*Clupea pallasii*) to determine if concentrations reflected environmental exposure from the geographic areas in which they reside. English sole from urban bays accumulated higher concentrations of PCBs than from near- or non-urban bays and concentrations in tissue and sediments were positively correlated. Highest PCB concentrations in rockfish were also observed in fish from urban bays. PCBs accumulated in older males but not in older females, who likely lose PCBs during reproduction with transfer of nutrients (lipids) to larvae. Higher PCB concentrations were also observed in Pacific herring, from the central Puget Sound basin where most of the urban bays are located, suggesting that PCBs present in discrete areas of marine sediments can be transported to the pelagic food web, distant from their source. Possible transport mechanisms include maternal transfer of PCBs from benthic feeding biota. PCBs were also detected in Pacific salmon with higher concentrations in chinook than coho. PCBs in adult coho returning to rivers in Puget Sound were highest in the central basin followed by the southern and northern basins.

Life at the Top of the Food Chain: Seabirds, Seals and Whales as Sentinels of Environmental Contamination in Puget Sound and Georgia Basin

Peter S. Ross

Institute of Ocean Sciences

Wildlife occupying high levels in aquatic food chains often accumulate high concentrations of persistent organic pollutants (POPs), including polychlorinated biphenyls (PCBs) and other endocrine disrupting compounds. Such species have therefore been used to provide information on the “state of contamination in the environment”, reflecting their effective integration of contaminant signals from the food web upon which they depend. The heavy contamination of Pacific killer whales with PCBs, for example, have provided evidence that British Columbia and Washington State are not immune to problems of industrial contamination. In an ecosystem-based approach to modelling PCBs in this transboundary environment, high trophic level wildlife offer several key features that bear consideration: high trophic level, long lifespan, and a reasonable assessment of population numbers, life histories and prey composition. In addition, seabirds and marine mammals often share ecological features with certain human consumer groups (e.g. subsistence or fishing communities). Marine mammals, in particular, are understandable (and appealing) to members of the public and to managers. Questions demanding scrutiny include food web structure, quality of dietary information, linkages to abiotic components, life history characteristics (age, sex, size, condition, season, population, longevity, reproductive output), migratory habits of the species in question and their prey, and metabolism. Documenting the relative importance of ‘local’ vs ‘external’ contamination will require an understanding of the biological movement of predator and prey, and air and water masses, across any boundaries designated for this basin-oriented model. The scientific and ecological utility of the information generated from studies of seabirds and marine mammals, coupled with the potential for outreach, ensures that high trophic level organisms represent a valuable component of characterizing contaminant pathways in Puget Sound and Georgia Basin.

Session 4F: HARMFUL ALGAL BLOOMS

Increased Magnitude, Frequency and Geographical Spread of Harmful Algal Blooms in Puget Sound

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National Marine Fisheries Service

Linda Hanson, Frank Cox and Judy Dowell

*Washington State Department of Health, Food Safety and
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Puget Sound has a long history of paralytic shellfish poisoning (PSP) in its northern basins. We have examined the general trends for PSP in Puget Sound using forty-five years of data collected by the Washington State Department of Health (WDOH). Although the dataset has certain limitations, including the lack of consistency in number of samples and collection sites, we conclude that the approximately ten-fold increase in maximal levels of paralytic shellfish toxins is not due to increased sample frequency. Since 1978, historically unaffected areas within southern Puget Sound have experienced more frequent and intense outbreaks of PSP indicating a southward spread of toxigenic algae over the past four decades. By 1988, the first shellfish harvest closures occurred in the southern areas of Puget Sound. A combination of factors may have contributed to this geographical spread including increased urbanization and population and the movement of *Alexandrium* cells and/or cysts past sills from northern Puget Sound into the central and southern basins.

Effects of a Common Marine Algal Toxin on Early Development and Behavioral Performance in Fish

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and Nathaniel L. Scholz

NOAA Fisheries

Algal toxins are detected extracellularly in both media of cultured toxic phytoplankton and in field-collected water samples obtained from bloom events. During harmful algal blooms, planktonic fish embryos and larvae are exposed to these dissolved toxins, yet little is known about their impacts on the developmental processes that establish the body plan and functional capacity of fish at early life history stages. Using zebrafish (*Danio rerio*) as a model system for fish development, morphological and behavioral effects of the dinoflagellate-produced neurotoxin, saxitoxin (STX), were examined. Additionally, the effects of STX on the visual system were investigated. Gross morphological aberrations (edema of the eyes, pericardium and yolk sac, and dorsal body curvature) and functional aberrations (delayed hatching, impaired optomotor function, reduced touch response, and complete paralysis) occurred at concentrations ranging from 112 to 350 ng STX equiv. ml⁻¹. To confirm STX concentrations in exposure media, samples were taken regularly throughout each experiment and STX was quantified using a receptor-binding assay. A discussion of the ecological relevancy of toxic doses and the potential implications for population and community level impacts will be presented.

Managing Important Recreational and Commercial Shellfish Fisheries Around Harmful Algal Blooms

Dan L. Ayres and Heather J. Reed

Washington Department of Fish and Wildlife

The two most important shellfish harvest activities that occur along the Pacific Coast of Washington State are the recreational Pacific razor clam (*Siliqua patula*, Dixon 1789)

and commercial Dungeness crab (*Cancer magister*, Dana 1852) fisheries. Participants in these two major fisheries have found their activities disrupted during the 2002-2003 fishing seasons by sudden increases in domoic acid levels in the tissues of these two shellfish species. For what will likely be the third time since its west-coast discovery in 1991, domoic acid has closed the culturally and economically important razor clam fishery, for at least one-year. The entire recreational seasons of 1991-1992 and 1998-1999 and 2002-2003 (to date) have been closed to protect the health of consumers from this potentially deadly toxin. These closures have resulted in a conservative estimate of more than \$20 million lost to the economies of already struggling coastal communities. In February 2003, the viscera of Dungeness crab taken in the coastal commercial fishery that occurs within Willapa Bay, Washington, exceeded the action level for domoic acid. The Willapa Bay fishery was closed immediately, resulting in the loss of fishing grounds to more than 20 active fishers. This marked the first time since 1991 that the Dungeness crab fishery has been affected by domoic acid. In addition, there have been several "close-calls" during the 2002-03 coast-wide Dungeness crab fishery (that opened December 10, 2002) with crab samples testing very close to domoic acid action criteria. This season with more than 200 active fishers, this fishery is expected to have an ex-vessel value close to \$60 million before it closes on September 15, 2003. Washington Department of Fish and Wildlife (WDFW) and Department of Health staff have met with industry representatives to develop a plan should the action level be exceeded. Currently, WDFW is actively participating in the federally funded Olympic Region Harmful Algal Bloom (ORHAB) project. This study provides the hope of developing an "early-warning" system to avoid the massive disruptions caused by last-minute fishery closures, while still protecting the health of thousands of consumers.

Paralytic Shellfish Poisoning: The Relationship Between *Alexandrium* Abundance and PSP Toxins on Kodiak Island, Alaska

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Paralytic Shellfish Poisoning (PSP) has severe negative impacts in Alaska. This study was designed to improve existing PSP monitoring programs by incorporating

phytoplankton monitoring. *Alexandrium* abundance was ascertained at a near shore site on Kodiak Island during 2000 and 2001 using species-specific LSU rRNA targeted oligonucleotide probes in whole cell (WC) and sandwich hybridization (SH) assay formats. *Alexandrium* abundance exhibited two distinct peaks (>400 cells/L) in 2000, both of which lasted approximately 2 weeks. *Alexandrium* abundance in 2001 was much more sporadic, with 4-5 peaks, each lasting only 3-7 days. In 2001, *Alexandrium* abundance tracked water column toxicity as determined via a ³H-Saxitoxin receptor-binding assay. Importantly, DNA probe data revealed a correlation between *Alexandrium* abundance and blue mussel (*Mytilus edulis*) toxicity in both 2000 and 2001. The results also demonstrated that increases in *Alexandrium* abundance preceded elevated toxin levels in shellfish suggesting that this method could prove useful as a monitoring tool to predict toxic events prior to shellfish harvest. Overall, this report provides compelling evidence that DNA probe chemistry can be used to estimate the abundance of *Alexandrium* in the field, however a number of problems must be rectified if the assay is to be used for monitoring purposes.

Seasonal and Interannual Variation in Blooms of *Alexandrium* spp. in the Strait of Georgia, Evaluated From Time Series of PSP Toxicity in the Sentinel Species *Mytilus californianus*

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The occurrence and distribution of PSP producing species of *Alexandrium* can be evaluated by bivalves, which are recent-time indicators of toxic bloom events. As toxin retention in bivalves is species specific, it is imperative that a standard sentinel species be used for comparative monitoring. A review of toxicity in *Mytilus californianus* collected by the Canadian Food Inspection Agency over the past 11 years indicated seasonal and inter-annual variance within and between collection sites in the Strait of Georgia. In general blooms of *Alexandrium* in the Strait occurred from May to December, but in some years no site-specific blooms were evident. Sites north of Departure Bay were infrequently high in toxicity. Highest toxicity in this area in the period of 1990 to 2001 was seen in Metcalf Bay at 430 µg STXeq/100g. However, south of Departure Bay, at Coffin Point, Vesuvius Bay, Burgoyne Bay and Patricia Bay high levels of toxicity were evident at two periods; May to August and September to December. Maxima of 4300 - 8800 µg STXeq/100g occurred at these sites in October 1997. Ganges Harbour, on the Strait side of Saltspring Island, exhibited only minor blooms of *Alexandrium* relative to Vesuvius and Burgoyne Bays on the west side, reflecting geographical/environmental effects on algal growth. On the exposed mainland side of the Strait, blooms of *Alexandrium* were minimal with the highest value of 730 µgSTXeq/100g recorded at Smugglers Cove/Halfmoon Bay in June 1993. Eleven year maximum toxicity in mainland inlet sites such as Okeover Inlet (October 2000;

3,200 µg STXeq/100g) in the north, and Agamemnon Channel (October 1992; 1500 µg STXeq/100g) in the south, illustrate clearly the geographic and temporal variations in *Alexandrium* bloom formation in the Georgia Basin.

Session 5A—Workshop DEVELOPING COMMON INDICATORS FOR A TRANSBOUNDARY INDICATOR REPORT

This session will focus on the practical issues and technical steps involved in identifying and developing common transboundary indicators. Five topic areas are examined for possible inclusion in the next Georgia Basin-Puget Sound bi-national indicators report:

- Water quality (fresh and marine)
- Water consumption/use
- Shellfish contamination
- Land use/development.

Session 5B: TRANSBOUNDARY AIR QUALITY (II)

Visibility Targets for the Lower Fraser Valley (LFV), British Columbia

Roger McNeill

Environment

Anne Roberge

Economic Consultant

Three research studies over the last eight years surveyed residents and tourists in the Lower Fraser Valley to assess visibility acceptance levels. The studies presented overhead projector displays of various levels of visible air pollution in different locations in the LFV to focus groups. The analysis from all three studies shows that perception of visibility and acceptable levels are dependent on factors specific to each vista, as well as the type and colour of the haze produced by air pollution. Based on these three studies, visibility targets are proposed and expressed as either one-day minimum visibility levels or as combinations of visibility levels over a ten day period. The studies also point out a potential discrepancy in perception of visibility changes over time compared to actual changes over the last 10 years. The relevance and utility of these types of public-acceptance targets vis-a-vis air quality standards based on benefit cost analysis are also discussed.

Atmospheric Concentrations of Semi-Volatile Organic Pollutants on the Tip of the Olympic Peninsula of Washington: Evidence of Trans-Pacific Transport?

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*Department of Environmental & Molecular Toxicology
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During Spring 2002, high volume air samples were collected for anthropogenic semi-volatile organic compounds (SOCs) at Cheeka Peak Observatory as part of the NOAA's ITCT 2K2 and University of Washington's PHOBEA2 campaigns. The samples were analyzed for a wide range of SOCs, including organochlorine pesticides, current use pesticides, and polycyclic aromatic hydrocarbons, in both the atmospheric gas and particulate phases. An Accelerated Solvent Extraction system was used to clean and extract the polyurethane foam plugs that were used to trap gas-phase SOCs and to extract glass fiber filters that were used to trap particulate-phase SOCs. The concentration of these SOCs in the air samples was correlated with air trajectories, and the concentration of other air pollutants, in an attempt to distinguish between Asian and North American emission sources.

Biomonitoring Atmospheric Deposition in the Georgia Basin, British Columbia

Beverley Raymond

Environment Canada

Deposition of atmospheric nitrogen, sulphur, and metals in the Georgia Basin is being investigated using a biomonitoring approach. The moss, *Isothecium stoloniferum*, and the lichens *Platismatia glauca*, *Parmelia sulcata*, and *Hypogymnia physodes* were sampled in the summers of 2001 and 2002 at four existing air quality monitoring stations. In addition, two of the four species were collected from about 50 locations distributed throughout the Georgia Basin in summer of 2002 to characterize atmospheric deposition in the Basin.

The moss and lichen samples from air quality monitoring stations will be used to calibrate levels of air pollutants in tissue versus levels in deposition. Nitrogen, sulphur, and metals are being monitored in wet deposition at these stations from November 2001 to December 2002. Canada's National Air Pollution Surveillance program also monitors these variables in particulates at three of these sites. Preliminary results from these tissue and wet deposition analyses will be presented.

Air Contaminant and Greenhouse Gas Emission Trends and Forecasts for the International Lower Fraser Valley Airshed

John Newhook, Kelly Der, Derek Jennejohn

Greater Vancouver Regional District

Every five years, the Greater Vancouver Regional District (GVRD) conducts a major Air Emissions Inventory (EI), as well as a trend analysis and forecast of future emissions.

The Year 2000 EI has been improved over previous versions, in that the most up-to-date methodologies have been used, as well as locally-generated data for such sources as residential wood burning and road dust. Also for the first time, ammonia has been added to the list of contaminants inventoried, and Whatcom County in Washington State has been added to the geographical area, making this the GVRD's first truly International Airshed EI. This Emissions Inventory and Forecast will be used by the Georgia Basin-Puget Sound International Airshed Partnership to help characterize the airshed, in developing cooperative initiatives to improve air quality in the Lower Fraser Valley, and in updating the GVRD's *1994 Air Quality Management Plan*.

Forecasting Ground-level Ozone in the Lower Fraser Valley

Edward Lord and Alex Cannon

Meteorological Service of Canada

During the summer of 2002, the Pacific Weather Centre, in cooperation with the Greater Vancouver Regional District and the B.C. Ministry of Water, Land and Air Protection, issued forecasts of daily maximum 1-h ozone concentrations for eleven regions in the Lower Fraser Valley. Pacific Weather Centre meteorologists, who were provided with guidance from three statistical models, prepared the forecasts twice daily. This presentation will describe the forecasting process and the statistical models used. A verification of the forecasts showed that root mean square errors ranged from a low of less than 2.9 units of the air quality index for ozone for very short-range forecasts, to 6.1 units for forecasts with lead times of 36 hours. Biases at all lead times were small. The statistical models provided very good guidance, with most forecasts simply replicating the model output. Forecasters intervened on only 3.8% of the regional predictions - 59.8% of those changes increased the accuracy of the forecast, 34.8% lessened the accuracy, and 5.4% of the changes had no effect. These results indicate that an automated ozone forecast for the Lower Fraser Valley using statistical models is feasible. Human intervention may only be required on rare occasions, most importantly when concentrations threaten to exceed the maximum acceptable federal objective.

Session 5C: SALMON HABITAT AND POPULATION STUDIES

Juvenile Salmon Utilization of Sinclair Inlet, an Urban Embayment

**Kurt L. Fresh, Doris Small, Hwa Kim, Mike Mizell,
Chris Waldbillig and Mark I. Carr**

Washington Department of Fish and Wildlife

Sinclair Inlet is a large, enclosed embayment located in Central Puget Sound where the quality of habitat, water and

sediment has all been significantly modified. Since 2001, we have investigated the ecology of juvenile salmonids, especially juvenile chinook, associated with littoral and offshore habitats of the Inlet using beach seines, surface trawls, and purse seines. We found juvenile chinook in littoral areas of Sinclair Inlet from April through the end of September when sampling ended. Juvenile chum occurred in littoral areas of the bay from March through September while coho were rarely caught. Juvenile salmonids were abundant along both shorelines and in all habitat types. Most juvenile chinook using the bay had been released from the Gorst Creek rearing ponds. We released a large number of marked hatchery juvenile chinook into Gorst Creek to evaluate residence time and found that the fish spent up to three months in the bay. There was also a steady increase in size of chinook caught in the Inlet that also indicates some chinook were rearing for extended periods in the Inlet. We also found large juvenile chum (> 150 mm) in the bay in late September, indicating extended use of the bay by this species as well.

Juvenile Salmonid Utilization Patterns in the Snohomish River Estuary

Mindy Rowse

Northwest Fisheries Science Center

Kurt Fresh

Northwest Fisheries Science Center

Studies of hatchery and wild juvenile salmonid utilization, abundance, distribution and migratory timing in the Snohomish River estuary are being conducted. We examined spatial and temporal patterns of habitat use by wild and hatchery chinook and coho salmon. We will investigate the transferability of these data to research conducted in other large river estuaries in the northwest. This information will help us identify areas for protection and restoration in estuaries throughout the Puget Sound basin. We conducted beach seining in the mainstem and tributary sloughs, and fyke trapping in blind sloughs. Preliminary results indicate temporal patterns of migration in the Snohomish River are similar to those found in other systems. Juvenile salmon were found in all areas of the complex system of mainstem, tributary, and blind sloughs, but fish primarily utilize the mainstem and tributary sloughs as a passageway. While juvenile chinook and coho salmon utilize complex tidal marsh habitats, the numbers of fish found in these systems in the Snohomish River estuary were less than found in comparable habitats in other large river estuaries. Further research will define the extent of utilization of tidal marsh complexes in relation to location in the estuary, availability during tidal cycles, and connectivity to other habitats.

Linking Habitat-related and Density- dependent Population Responses in Chinook Salmon

Correigh Greene, Tim Beechie and Mary Ruckelshaus

Northwest Fisheries Science Center

Efforts to improve the viability of salmon populations depend on understanding the consequences of habitat change, but our ability to predict these consequences is often hampered by a poor understanding of habitat relationships and their effects on population dynamics. We constructed a watershed-scale Leslie matrix model of chinook salmon that specified residency in redds, streams, tidal deltas, nearshore habitats, and the ocean. Using this model, we compared the relative importance of different habitats under several different density dependent scenarios: density independence throughout the life cycle, density independent survival with a spawning capacity (a “hockey stick” model), density-dependent survival in the streams and tidal delta, and density-dependent movement among streams, delta, and nearshore. All scenarios indicated that population dynamics were most sensitive to changes in nearshore and ocean mortality. However, sensitivity to changes in freshwater and delta productivity and capacity varied among the different density-dependent scenarios. These findings indicate that 1) nearshore habitat relationships may play particularly significant roles for salmon population dynamics and 2) the relative importance of stream and tidal delta habitats will largely depend upon the form of density dependence influencing salmon stocks.

Early Upstream Migration and Mortality of Late-run Fraser Sockeye Stocks

Michael F. Lapointe

Pacific Salmon Commission

Late-run stocks are unique among Fraser River sockeye salmon populations in that they typically delay in Georgia Strait 4-6 weeks prior to migrating upstream to spawn. Beginning in 1995, and continuing through 2002, this delay period has shortened, resulting in earlier than normal upstream migration to the point that in 2000 and 2001, fish entered the Fraser River 4-6 weeks earlier than normal. Each year, the early river entry has been associated with high rates of en-route and pre-spawning mortality (>90% in 2000 and 2001). The Pacific Salmon Commission has funded several studies to begin investigating the causes of this behavior and a large radio tagging was conducted in 2002. However, the cause of the behavior remains unknown. The abnormal behavior was less extreme in 2002 than the prior two years and the radio tagging results indicate that individual late-run sockeye exhibited a range of behaviors from little or no delay to near normal delay. The abnormal behavior and subsequent mortality is already threatening the viability of small populations (e.g. Cultus Lake sockeye). Precautionary management actions have resulted in large foregone catches of late-run and summer-run sockeye populations that co-migrate with late-run stocks in the fishing areas (e.g. Adams and Horsefly River sockeye). Similar behavior has been observed in other Fraser River salmon species, but the high mortality rates have not yet been observed.

Distribution and Abundance of Hatchery and Wild Juvenile Chinook Salmon in Nearshore Waters of Skagit Bay, Puget Sound, Washington

Casey Rice

NOAA/NMFS

Eric Beamer

Skagit System Cooperative

Dan Lomax

NOAA/NMFS/NWFSC

Rich Henderson

Skagit System Cooperative

George Pess

NOAA/NMFS/NWFSC

Adipose fin clip and coded wire tag marking of sub-yearling released hatchery chinook in the Skagit River system has been close to 100% since 1995. This provided a unique opportunity to compare wild and hatchery fish throughout the Skagit River basin, including the relatively understudied estuarine and marine environments. From May through October 2001, and February through October 2002, we conducted surface trawl (tows) studies exploring the differences in hatchery and wild juvenile chinook salmon abundance and distribution in the nearshore waters of Skagit Bay. During the sixteen monthly sampling trips thirteen sites were visited, and over 450 10-minute tows were completed. Eight of the thirteen tows sites were adjacent to beach seining locations where a total of over 900 beach seine sets were completed. We found that wild chinook showed broader distributions than hatchery chinook with respect to time, space, and individual size. Chinook presence in tows samples persisted later in the year than in beach seine samples. The overall proportion of wild chinook in tows catches was significantly lower than in beach seine samples. These results suggest that wild chinook utilize nearshore estuarine habitats more fully than do hatchery chinook.

Chemical Habitat Quality: A Major Source of Uncertainty in Salmon Recovery Planning

Nathaniel L. Scholz and Tracy K. Collier

NOAA Fisheries

Salmon recovery planners are increasingly faced with the following question: how should habitat restoration activities be ranked for river systems and estuaries that have mixed chemical and physical degradation? This is a key question for natural resource managers who must confront the complex impacts of urbanization, agricultural land uses, and industrial activities on salmon habitats in Puget Sound and the Georgia Basin. Obviously, where pollution occurs, habitat-based recovery models for salmon should address the potential significance of chemical habitat deterioration. Unfortunately, specific determinants of chemical habitat quality (i.e., water and sediment contamination) are often excluded from habitat models. This is because (1) chemical habitat quality can be very complex and expensive to measure, and (2) there is a general absence of relevant

toxicological data for most of the chemicals that salmon are exposed to. In the absence of empirical data for pollution, habitat recovery plans have generally placed a higher priority on the restoration of physical processes. Critically, this practice may undervalue the importance of chemical habitat quality and lead to predictive errors in recovery planning. To address these uncertainties, we provide examples of ongoing research designed to bridge the gaps between toxicology and the implementation of conservation measures for salmon.

Session 5D: INFORMATION AND DECISION SUPPORT TOOLS FOR LANDSCAPE ANALYSIS

Washington State Digital Coastal Atlas

Cinde Donoghue

Department of Ecology, SEA program

This interactive mapping site allows you to access and analyze geospatial data and aerial photos for Washington's coastal region. When you access this site you are querying actual databases rather than viewing static pictures of maps. This gives you some ability to analyze data from your desktop without using expensive GIS software. Information that is currently available for viewing includes historic and recent habitat maps, physical features such as unstable slopes watershed boundaries and predominant drift, and human modifications such as roads, railroads, dams and discharge points. This site is alive; the Department of Ecology is working on bringing more data into the atlas to improve public access to information regarding the Washington's coastal ecosystems. We intend to fully integrate the atlas into our coastal management web site as it is developed. Together these sites will provide guidance on characterizing shorelines for local planning, and allow the user to view and download much of the cited data.

Landscape Tools for Protecting and Restoring Aquatic Ecosystems

Stephen Stanley and Susan Grigsby

Department of Ecology

Washington state Department of Ecology is currently developing guidance to assist local governments in the application of landscape principles to planning and regulatory activities. This includes methods for a focused watershed analysis to address water quality problems and a web-based tool for evaluating a wetland mitigation project.

The focused watershed analysis was applied in the Drayton Harbor watershed just south of Blaine, Washington. It was conducted in order to develop specific land use recommendations and restoration measures that would potentially result in the restoration of ecological processes, structure and functions related to the improvement of water quality in Drayton Harbor and the contributing basins of Dakota and California Creeks.

Through analysis of several data layers (water sampling data, land use, soils) a clear correlation was detected between land use alterations and changes to the water and nutrient processes within both California and Dakota Creek basins. An overlay of "potential wetlands" allowed for the identification of the most effective locations for restoration of wetlands and riparian habitat.

The web-based tool guides the user through steps to evaluate the appropriateness of a wetland mitigation project by evaluating a particular site in terms of its landscape position.

Using the Relative Risk Model for a Regional Scale Ecological Risk Assessment and Risk Prediction to Management Options of the Squalicum Creek Watershed (WA, USA)

Joy C. Chen

Jones & Stokes

Wayne G. Landis

Western Washington University

A two-part ecological risk assessment of the Squalicum Creek watershed (SCW) was conducted using the Relative Risk Model (RRM). The objectives of this assessment were to:

- (1) Rank multiple stressors and land uses according to their relative contribution of risks to the endpoints.
- (2) Determine the relative risks of each habitat and endpoint in the SCW.
- (3) Predict the effects of decision options on the watershed.

The RRM, a rank-based method, was used due to its ability to quantify risks in multiple geographical-scale areas with multiple stressors, habitats and receptors. Results from Part I showed that the risk regions with the most overlapping of relatively high rank stressor sources and habitats, accompanied by the specific source-endpoint exposure pathways, were found to have the highest risk. Salmonids were found to be at relatively low risk because of limited habitat due to impassable culverts. Results from Part II indicated that in most cases, stressor sources and stressors reduction could lower more risk to endpoints than habitat creation. The assessment results enable various authorities to have a common set of priorities for the parcels and the RRM allows the decision makers to predict the effects of management decisions on the system.

Wildlife Inventories in the Boundary Bay Watershed

Anne Murray

*Immediate Past-President of the Federation of B.C.
Naturalists*

Boundary Bay is a globally significant site for migratory and wintering birds, spanning the border between British Columbia and Washington. Apart from some bird studies, there has been no previous attempt to document the wildlife use of the bay and associated uplands and watershed. This

ecosystem contextual information is essential for assessing the impact of individual developments and landscape changes on wildlife populations.

I set out to build a comprehensive inventory of mammals, birds, reptiles, and amphibians using this important area. I performed an extensive literature review and contacted naturalists, government agencies, museums, biological consultants, and numerous experts. I determined which species have been recorded in the last ten years (confirmed sighting or specimen), or are highly likely to occur, and which were present in the recent past or historically.

My results show that at least 306 bird, 59 mammal, seven reptile and eleven amphibian species have been recorded in the Boundary Bay area in recent times, or are considered as likely to occur. Four native mammals are confirmed extirpated. New questions arise: the interaction between introduced species and native ones is not well understood and very little is known about nocturnal species. There is much scope for further study.

GBEI Coast Salish/Sto:lo Nation Environmental Inventory

Francine Roulston

Sto:Lo Nation

From leachate, heavy metals, to the loss of traditional use areas, this environmental inventory has uncovered substantially warranted enough evidence for its continuation within Sto:Lo Territory. Through investigation, reports, the gathering of water and soil samples, the discovery of abnormal materials are being revealed throughout the Reserves and are posing health risks to the people and environment. The goals of this project are to establish an inventory database identifying these problems within Sto:Lo Territory then undertaking the perplexity of distribution through a task force implemented by the proper inter-agencies to extricate these issues. This project also gives the communities a conduit in which to bring forth any undiscovered materials or areas for identification. This project was initiated in March 2001 in conjunction with the Georgia Basin Ecosystems Initiative, Environment Canada, Coast Salish Sea Initiative and the Sto:Lo Nation. This ongoing project will continue the assemblage of anomalies including the mistreatment of herbicide, pesticide, agricultural practices and locating the sources of contaminants. The GEBI/Coast Salish/Sto:Lo Nation Inventory Project is situated in Chilliwack BC and the project covers Yale to Kwantlen First Nation Langley.

British Columbia's Decision Support Tool for Hydrologic and Fisheries Applications

Mark Sondheim and Pete Lewis

Ministry of Sustainable Resource Management

The Ministry of Sustainable Resource Management, Province of British Columbia is currently working on producing an intelligent aquatic database called the Corporate Watershed Base (previously known as the TRIM

Watershed Atlas (TWA)). The CWB is a collection of hydrographic features stored in an object-relational database derived from the TRIM 1:20 000 data.

The CWB is intended to address fisheries and hydrographic concerns, including support for upstream queries pertaining to both streams and basins. The underlying schema addresses the hierarchical structure of the stream network and is consistent with the emerging Canadian GeoBase inland waters model.

Management of the system will be integrated tightly with that of the TRIM Base Mapping program as well as that of the Digital Road Atlas (DRA). The overall architecture includes the ability to update by both government and non-government personnel. Access and distribution will make us of Open GIS Consortium (OGC) web services, thus enabling interoperability.

The project is approximately 50% complete and considerable effort is being made to finish the provincial hydrographic network, which is the cornerstone to this product. When complete the CWB will provide support to science based decisions by enhancing the ability to link spatial and attribute data about aquatic features and it will also serve as a suitable base for monitoring watershed phenomena.

Session 5E—Workshop: DEVELOPING A RESEARCH PROPOSAL ADDRESSING PCBs IN GEORGIA BASIN/ PUGET SOUND

This session will build on perspectives that emerged from a recent workshop on PCBs in the region. The presenters were involved as workgroup chairs in that workshop and are now developing a research program.

Session 5F—Workshop: GLOBAL PROGRAM OF ACTION FOR PROTECTION OF THE MARINE ENVIRONMENT FROM LAND-BASED SOURCES

Canada's National Programme of Action (NPA): Managing Shared Waters

This session will present Canada's National Programme of Action for the Protection of the Marine Environment from Land-based Activities, a collaborative federal-provincial-territorial governance approach to achieving integrated water management. It will also include a discussion, involving Canadians with an interest in managing shared waters, reflecting on how the NPA can be operationalized on the west coast.

Session 6A: HABITAT RESTORATION PROJECTS

Rehabilitating River Valley Ecosystems: Examples of Public, Private, and First Nation Cooperation in Western Washington

Tim Abbe

Herrera Environmental Consultants

Michael McHenry

Lower Elwha Nation

Keith Dublanica

Skokomish Nation

Andy Ritchie

Makah Nation Fisheries

Maeve McBride and Mark Ewbank, P.E.

Herrera Environmental Consultants

Prior to European colonization, lowland forest rivers of the coastal Pacific Northwest occupied vast areas interspersed with complex networks of perennial and ephemeral channels. Floodplains mantled in complex mosaics of forest patches and wetlands were integrally linked to these channel networks. One of principal components driving the complexity of these systems was the presence of logjams which split flow, raised water levels, created pools, and provided abundant cover for salmon. Several efforts underway on the Olympic Peninsula of Washington State provide examples of integrating a valley-scale approach to rehabilitating salmonid habitat. Projects in these rivers are constructing logjams as a key element in re-creating channel complexity in cooperative efforts with local private landowners, public agencies and First Nations. Other rivers where "hands-off" management of riparian forests has led to the natural formation of large logjams, such as on the Green, Nisqually and Deschutes Rivers in the Puget Sound area demonstrate that natural processes can still create the complex and rich ecosystems. But the rehabilitation of forest river corridors can have significant consequences to infrastructure and development which communities should understand and be prepared to accommodate.

Galiano Forest Restoration Project

Keith Erickson

Galiano Conservancy Association

Up until 150 years ago, over 75% of the forest landscape of East Vancouver Island and the adjacent Gulf Islands was dominated by trees greater than 100 years of age. Today only 2.6% of the same landscape is characterized by older forest (McPhee et al., 2000). Regenerating forests, agricultural lands, roads and urban development have replaced and fragmented old forest, making ecosystems of the Coastal Douglas-fir Biogeoclimatic Zone some of the most endangered in BC. Although the protection of remaining old forest is essential, the sheer rarity of these opportunities dictates that we must also focus on the protection and subsequent restoration of degraded land.

This project will put into action a detailed restoration plan developed for a 160 acre plantation forest on Galiano Island. Restoration activities will help to increase the structural, species and genetic diversity within the single-species, single-storied Douglas-fir plantation. Activities include the dispersal of coarse woody debris, erection of wildlife trees, thinning treatments and reclamation of landing and gravel pit sites.

This project will provide the research, methodology, evaluation, and monitoring information required for a successful forest restoration project. It will also contribute to the monitoring of long-term global environmental change through the Smithsonian Institute's Monitoring and Assessment of Biodiversity program.

A Tidal Habitat Restoration Success Story— The Union Slough Restoration Project

Jonathan P. Houghton and Leslie Uhlig

Pentec Environmental

In February 2001, dikes were breached to restore tidal circulation to a ± 20 -acre, former agricultural parcel along Union Slough in the lower Snohomish Estuary, near Everett Washington. Before dike breaching, the site was graded to provide desired elevations for brackish marsh development, and to provide a deep dendritic channel that would allow maximum accessibility by juvenile salmonids; also, a new inner dike was built to protect Interstate 5 from flooding.

Substantial numbers of small invertebrates and fish were using and feeding in the site as early as the April following dike breaching. Summer and fall seining demonstrated use by 6 species of juvenile anadromous salmonids with chinook and coho juveniles remaining in the site through November, 2001. Benthic productivity appears to be high and a variety of shorebirds and waterfowl have been observed. Marsh vegetation has rapidly colonized elevations between about +7 and +11 feet MLLW and several pieces of large woody debris recruited to shorelines within the site during winter 2001–2002 flooding. This and several other sites in the Snohomish Estuary clearly demonstrate that breaching dikes to restore tidal action is a relatively certain and often low-cost means of providing real and immediate increases in habitat function.

South Buttle Lake (Reservoir) Shoreline Revegetation

Scot MacKillop and William (Bill) Dushenko

Royal Roads University

The management of Buttle Lake for the production hydroelectric power causes unnatural fluctuations of water level resulting in sparsely vegetated shoreline. Growth measurements (caliper and height) and survivorship of seedlings planted at surveyed elevations will be statistically analyzed. The values for three native tree and three native shrub species will indicate the species responses to calculated levels of inundation. The research project is designed for long-term monitoring and comparison to

natural successional patterns. This information set will lead to improved revegetation strategies for drawdown zones and other similarly flooded habitats where fish habitat enhancement or similar needs are required. Ongoing Water Use Planning (BC Hydro) and Watershed-based Fish Sustainability Planning (BC and Canada) ultimately relies upon scientifically sound information to effectively manage the complex function of a watershed. Understanding the limits of riparian rehabilitation in hydro managed watersheds is critical to the success of planning efforts and the ecological sustainability of future habitat restoration projects in such watersheds.

Habitat Restoration in the Georgia-Pacific Log Pond, Bellingham

Clay R. Patmont

Anchor Environmental

Brian L. Bingham

Western Washington University

R. Chip Hilarides

Georgia-Pacific

Paul T. Schlenger

Anchor Environmental

In early 2001, Georgia-Pacific (G-P) completed construction of a combined sediment cleanup/habitat restoration project at the G-P Log Pond in Bellingham Bay. The project converted subtidal mudflat/debris and low intertidal riprap, all of which previously exceeded Washington State sediment quality standards, into clean intertidal and shallow subtidal silt and sand habitat. This project provided the opportunity to monitor improving habitat functions that the area now provides to salmon and their prey. Pre- and post-construction monitoring activities in the Log Pond have included detailed chemical monitoring, epibenthic/benthic organism monitoring, and juvenile salmonid sampling. Sediment, water, and biological tissue quality in the site area continues to be maintained within state standards protective of habitat functions. Monitoring results indicate that within several months of construction, epibenthic and benthic biomass, species richness, diversity and evenness within the Log Pond were similar to or better than levels seen at local reference stations. A comparison of pre- and post-construction monitoring results suggests increased utilization of the Log Pond by juvenile salmonids. Capping with clean sediments appears to be an effective method of concurrently achieving cleanup and habitat restoration goals for this site. Additional integrated cleanup and habitat restoration projects in Bellingham Bay will be discussed.

Parks Canada Participation in Garry Oak Ecosystems Recovery

Brian Reader

Parks Canada Agency

Garry oak ecosystems occur in a localized and unique area of Mediterranean climate due to the combined rain shadow from two mountain ranges. Perhaps as little as

1% of Garry oak ecosystems remain in Canada, which has resulted in a very high concentration of species at risk. To address conservation concerns in this area the Garry Oak Ecosystems Recovery Team has prepared a multi-species ecosystem-based recovery strategy and is working in collaboration with over 80 agencies and individuals to help restore habitat and species in this region.

Parks Canada has interests in the restoration and ecological integrity of Garry oak ecosystems for several reasons:

- Parks Canada is one three Federal Departments responsible for delivery of Canada's National Accord for the Protection of Species at Risk.
- Parks Canada is identified as a responsible ministry for species at risk in Canada under Canada's proposed Species at Risk legislation.
- Parks Canada has a strong conservation mandate.
- Parks Canada has protected areas in this region and is creating a new national park in the Gulf Islands within the range of Garry oak ecosystems.

Parks Canada currently chairs the Garry Oak Ecosystems Recovery Team and participates on many of the Recovery Action Groups. Parks Canada has also been conducting invasive species control and research and compiling baseline data on lands under their jurisdiction. As the proposed Gulf Islands National Park is developed an accelerated program of study and recovery action is envisioned.

Session 6B—Panel SCIENCE/DECISION-MAKING INTERFACE

This session will explore the use of science-based information by the Greater Vancouver Regional District in British Columbia; by local governments in Washington State; and in the energy sector, by BC Hydro.

- **Ken Cameron**, Manager of Policy and Planning for the Greater Vancouver Regional District, "A Risk Assessment Approach to Using Science for Decision-making"
- **Chris Parsons**, Growth Management Planner, Office of Community Development Washington Department of Community, Trade and Economic Development, "Assessing Scientific Information for Reliability and Local Application"
- **Bruce Sampson**, Senior Vice-President, Strategic Planning & Sustainability, BC Hydro, "Integrating Science-based Information in a Triple Bottom Line Approach"

Session 6C: PHYSICAL AND BIOLOGICAL OCEANOGRAPHY (I)

A Comparison of Predicted Cross-Channel Flows from an EFDC-based Model to ADCP Data in South Puget Sound

Skip Albertson, N. Larson and J. Newton

Washington State Department of Ecology

In order to understand the relationship between human activity, climate change, and Puget Sound, several three-dimensional hydrodynamic modeling efforts are currently underway coordinated through a partnership of federal (Navy), university (U Wash), state (WA Ecology), local (King County) and non-profit (Ocean Inquiry Project) institutions, funded through the National Oceanographic Partnership Program. Some of the most important quantities predicted by any model are the velocities and transports that will affect all other parameters in the model via advection. We take predicted velocities from an Environmental Fluid Dynamics Code (EFDC)-based model developed for South Puget Sound by Ecology and compare these to Acoustic Doppler Current Profiler data collected along select transects in Carr and Case Inlets. We intercompare barotropic ebb and flood tides to see how well the model duplicates cross-channel variability. In addition, we average ebbs and floods from a synodic day from both model and measured ADCP output to determine the baroclinic mean (residual) flow. The degree to which this can be done successfully in this region of high tidal exchange is a function of how much residual flow is present. Carr Inlet appears to have significantly less residual flow than Case Inlet.

Patterns of Larval Settlement are not Predictable from Coarse Measures of Surface Circulation

Terrie Klinger and Janine Kido

University of Washington

The dispersal of larvae between sites is recognized as an important factor in Marine Protected Area (MPA) network design. To evaluate the correspondence between circulation and realized dispersal, we used passive drifters to coarsely describe local surface circulation in the San Juan Archipelago (WA). We then made predictions concerning the distribution of larvae and adults according to the results of the drifter study. We found no significant positive correlation between the distribution of passive drifters and the average intensity of larval settlement or species richness. These results indicate that coarse measures of local ocean circulation provide insufficient basis for predicting larval settlement. More sensitive measures of circulation and the incorporation of larval behavior may improve predictive capabilities for the purposes of MPA network design.

Year-long Current Measurements in Puget Sound's Triple Junction

Bruce Nairn

King County Department of Natural Resources and Parks

Curtis Ebbesmeyer

Evans-Hamilton, Inc.

Glenn Cannon

School of Oceanography

Within Puget Sound, three arms (Admiralty Inlet, Main Basin, Possession Sound) join in a region known as the Triple Junction. To assist in the siting of King County's BrightWater outfall, currents were measured in the Triple Junction from July 2000 to January 2002. All totaled, 56 current meters were deployed for periods of a month or longer.

The current meters were primarily placed along east-west transects to document patterns of currents across the main axes of the Triple Junction. We present an overview of the observed current structure, for both tidal and low-frequency (tidally-averaged) currents. Observations included significant horizontal and vertical variations, which are used to suggest some of the underlying mechanisms affecting the circulation in the Triple Junction region.

Undergraduate Oceanographic Research: A Longitudinal Transect of Puget Sound, May 2002 & Historical Comparison

Wynnae M. Osenga, Cynthia B. Tomkins and Cheryl L. Greengrove

University of Washington

During the spring of 2002, undergraduate students at University of Washington, Tacoma and Seattle jointly participated in a survey of Puget Sound aboard the R/V Thompson as part of courses offered at each campus. This provided a unique opportunity to obtain a rare longitudinal transect of hydrographic data extending from 100 nm offshore through the Strait of Juan de Fuca and the Main Basin to the Nisqually Delta. Data collected includes temperature, salinity, dissolved oxygen, chlorophyll-a and nutrients. We will present our analysis of the vertical and horizontal distribution of these physical and chemical oceanographic properties, as well as evaluate temporal characteristics by comparing these parameters with available historical data.

Drift Cards From Puget Sound Found in Juan de Fuca Strait

Kari Sauers

Evans-Hamilton, Inc.

Terrie Klinger

University of Washington

Carol Coomes and Curtis Ebbesmeyer

Evans-Hamilton, Inc.

Drift cards have been used repeatedly in surface circulation, habitat, and environmental studies. Between August 2000

and December 2001, we released 6,100 drift cards in Puget Sound's Main Basin as part of the oceanographic studies associated with the siting of King County's new BrightWater outfall. Fifty-one percent of these cards were reported, mostly in Puget Sound, including 417 in the Strait of Juan de Fuca and on the Pacific coast. Previous studies of drifters in the eastern strait focused on releases from Georgia Strait and western Juan de Fuca Strait. This study adds new data from cards entering the Strait of Juan de Fuca from Puget Sound and provides the opportunity for new syntheses of recent and historical regional drift card studies.

Despite their more southerly origins, the cards were recovered from collection zones identified in previous studies. Additionally, many were recovered in Marine Protected Areas (MPAs) within the region. Our results indicate that Dungeness Spit, Victoria Bight, and Whidbey Island are all likely to receive elevated levels of drifting material, indicating their potential importance in regional MPA network design. Cards were also recovered from Hawaii and Alaska, indicating the potential for low-frequency, long-distance dispersal events.

Session 6D: INFORMATION AND DECISION SUPPORT TOOLS FOR LANDSCAPE PLANNING

Land Use Impacts in the Elk Creek Watershed in Chilliwack: A Multi-media Public Information System

Regina Bestbier

University of British Columbia

Over the past 5 years a number of federal, provincial, and municipal agencies and UBC conducted a variety of research projects in the Elk Creek watershed near Chilliwack. Intensive agriculture is dominant in the lower portion of the watershed and the steep headwaters are under forest cover, which is slated for urban development in the near future. A multi-media CD-ROM was created to combine the results of all the studies and to produce an interactive information system for community education and for providing a scientific basis to assist decision making. The CD-ROM provides up to date information on the status of biophysical resources and the impact of land use on water quality and aquatic resources. The status of the atmospheric pollutants in the watershed and the surplus nutrients applied to the land were quantified to show the external inputs on the land and water resources. The results of the watershed assessment are in the form of interactive GIS maps, images and graphs and management challenges are highlighted. The results show that the aquatic resources are under stress and the cumulative effect of all land uses is clearly visible in the downstream direction of the stream.

UrbanSim—A Tool for Land-Use Planners

Paul Waddell

University of Washington, Urban Design and Planning

Sensitive Shoreline Assessment: A Multimedia Decision Support Tool

Anthony Gabriel

Central Washington University, Geography and Land Studies

L. Bodensteiner

Huxley College, Western Washington University.

The purpose of this paper is to present a Sensitive Shoreline Assessment decision support tool that was used to designate and ecologically characterize sensitive shorelines for the Winnebago Upper Pool Lakes, Wisconsin. Following initial, coarser scale, scoping assessments, the sensitive shorelines were designated and assessed using Wisconsin Department of Natural Resources guidelines and protocols, augmented by a variety of existing classification indices. The result was an environmental folio and multimedia database that synthesizes, integrates, graphically displays, and provides modeling capabilities which incorporate biophysical and cultural information for sensitive shorelines. The folio consists of maps and text built around the ecological structure and functions of 39 sensitive shorelines, as well documents the major concerns and issues facing the inhabitants and managers. The Sensitive Shoreline Assessment methodology combines field assessments with geographic information system (GIS), remote sensing, image processing, and multimedia technologies to develop: 1) a spatial database in GIS format and a multimedia database for sensitive shorelines; and 2) an integrated multimedia approach for easy access to the digital databases. The procedures performed in this project can be further employed to other shorelines.

Linking Data and Analytical Tools through RAINS

John Schweiss

US Environmental Protection Agency,

Session 6E: MARINE SEDIMENT CONTAMINANTS

Contaminant Mass Balance for Sinclair and Dyes Inlets, Puget Sound, WA

Eric Crecelius

Battelle Marine Sciences Lab

Robert K. Johnston

US Navy Space and Naval Warfare Systems Center

Martin Miller and Jill Brandenberger

Battelle Marine Sciences Lab

Jim Leather and Joel Guerrero

US Navy Space and Naval Warfare Systems Center

Sinclair Inlet and Dyes Inlets have historically received contaminants from military installations, industrial activities, municipal outfalls, and other nonpoint sources. For the purpose of determining a "total maximum daily load" (TMDL) of contaminants for the Inlets, a contaminant mass balance for the sediments is being developed. Sediment cores and traps were collected from depositional areas of the Inlets and surface sediment grabs were collected from fluvial deposits associated with major drainage areas into the Inlets. All sediment samples were screened using X-Ray fluorescence (XRF) for metals, UV fluorescence for organics (PAHs), and immunoassay for PCBs. A subset of split-samples was analyzed using ICP/MS for metals and GC/MS for phthalates, PAHs, and PCBs. Sediment cores were age-dated using radionuclides to determine the sedimentation rate and the history of sediment contamination. Streams and storm water outfalls were sampled in both the wet and dry seasons to assess loading from the watershed. Seawater samples collected from the marine waters of the Inlets and boundary passages to central Puget Sound were used to estimate the exchange of contaminants with central Puget Sound. The historical trends from the cores indicate that contamination was at a maximum in the middle of the 1900s and decreased significantly by the late 1900s. The thickness of the contaminated sediment is in the range of 30 to 50 cm.

Revision of the Puget Sound Ambient Monitoring Program (PSAMP) Sediment Component Sampling Design

Margaret Dutch, Sandra Aasen, Valerie Partridge, Kathy Welch and Ed Long

Washington State Department of Ecology.

The Washington Department of Ecology's Marine Sediment Monitoring Team (MSMT) is currently revising the Puget Sound Ambient Monitoring Program (PSAMP) Sediment Component. With assistance from EPA and regional stakeholders, the current probabilistic sampling design has been refined using a spatially-balanced, generalized random tessellation stratified (GRTS) multi-density survey design, and a revised list of sampling parameters is being generated. A nested set of sampling frames, including

the whole sound, eight Puget Sound sediment sampling regions, and 5 strata within each of the 8 regions has been defined and will be sampled on a rotational cycle, alternating 7 years of regional sampling with 3 years of focus embayment sampling or focus analyses. Results will include annual spatial extent characterization of sediment quality (based on the sediment triad of toxicity, chemistry, and benthic infauna), along with temporal comparison of annual data and analyses to sediment baseline data. Details of this refined study design are described, and comment on the design is solicited.

Relationships Among Elements of the Sediment Quality Triad in Puget Sound

Edward R. Long, Margaret Dutch, Sandra Aasen and Kathy Welch

Washington State Department of Ecology

M. Jawed Hameedi

NOS/NCCOS/CCMA

Surficial sediment was collected at 300 locations during 1997-99 from the U.S./Canada border to the inlets of southern Puget Sound and Hood Canal. Statistical and graphical analyses were performed to quantify and illustrate the relationships among measures of chemical contamination, acute toxicity in laboratory tests, and indices of benthic infauna community structure in the sediments. Correlation and principal components analyses indicated a recurring pattern: one or more of the four toxicity tests indicated increasing toxicity as the concentrations of mixtures of organic substances and trace metals increased among sampling locations. Indices of contamination by complex chemical mixtures were very important variables Sound-wide; however there were significant differences in the composition of the mixtures among the urban bays. Gradients in chemical concentrations and toxicity were accompanied by losses in abundance of sensitive benthic species that lead to declines in total numbers of species and numbers of dominants. Losses in sensitive species overshadowed the increases in abundance of several pollution tolerant organisms. One or more physical factors (water depth, salinity, TOC content, or grain size) were invariably as important as the chemical variables and, therefore, probably contributed to the accumulation of the toxicants in the sediments and the composition of the benthos.

Sediment Quality at Ten Long-term Monitoring Stations in Puget Sound, 1989-2000

Valerie Partridge, Kathy Welch, Sandra Aasen and Margaret Dutch

Washington State Department of Ecology

As part of the Puget Sound Ambient Monitoring Program, the Washington Department of Ecology sampled sediments at ten sites in Puget Sound for trends in infauna (1989-2000) and changes in contaminants (1989-1996, 2000). The stations were located mainly away from sources of contaminants. Metals concentrations decreased at five of

the ten sites, while PAHs increased at several locations. Sinclair Inlet had the highest metals concentrations of all sites, with mercury levels consistently exceeding sediment quality standards. PAH levels in Thea Foss Waterway were 20 to 30 times higher than at other locations. Benzoic acid results were an order of magnitude higher everywhere in 2000 than in 1989-1996; however, those increases may have been artifacts of improvements in laboratory analysis. Few other contaminants were detected, indicating generally uncontaminated sediments. There were significant changes in infaunal communities at several sites that appear to be related to changes in sediment characteristics (e.g., grain size and contaminant levels).

Sediment Quality Assessment of the Iona Deep-Sea Outfall Area, 2000-2002

Albert van Roodselaar and Stanley Bertold

Greater Vancouver Regional District (GVRD)

Howard Bailey and Cathy McPherson

EVS Environment Consultants

Michael Paine

Paine, Ledge and Associates

The Iona Island Primary Wastewater Treatment Plant is one of five major primary and secondary treatment plants owned and operated by the GVRD. As committed in the Liquid Waste Management Plan, the GVRD carries out environmental monitoring and assessments of its municipal liquid waste discharges. Annual monitoring of the Iona discharge and vicinity has been performed since 1986, which includes two years of pre-discharge monitoring and 15 years of post-discharge monitoring and has included a variety of monitoring components. As determined by effluent dispersion and solids deposition modelling, effluent and effluent solids from the Iona Deep-Sea Outfall have a net northward transport due to prevailing currents and, therefore exposure to the Iona discharge is not simply a function of distance relative to the outfall. Three measures were used to quantify exposure: sediment fecal coliform concentrations, sediment coprostanol concentrations, and estimated maximum annual deposited solids loads. These parameters were used to derive a composite exposure measure. The exposure parameters were strongly positively correlated, with similar spatial distributions that yielded the expected peak north of the outfall accompanied by sharp decreases to the north and south. An analysis of the spatial patterns and variation in sediment concentrations of contaminants of potential concern was conducted. Sediment contaminant concentrations were compared to relevant marine sediment quality guidelines, reference sites and pre-discharge values, as well as biological metrics. One of the problems with using a correlational approach to identify relationships between chemical parameters and biological responses is that many effluent variables are correlated with each other. Because a number of variables may be related to biological parameters on a ranking basis, changes in concentrations among sites may be used to determine if these concentrations are consistent with the degree of biological response.

Session 6F—Panel : BRITISH COLUMBIA/ WASHINGTON ENVIRONMENTAL COOPERATION COUNCIL MEETING

Meeting of a transboundary body that coordinates action and information on shared environmental issues. Formed in 1992 by the Premier of British Columbia and the Governor of Washington.

Session 7A: STEWARDSHIP-COMMUNITY APPROACHES (I)

Community Asset Mapping: Engaging Youth with their Environment

Jackie Amsden

Environmental Youth Alliance

The future of strong local communities, and the rich cultural and natural resources that they steward, lies with youth. Yet, increasingly it is the youth that feel little connection to their home places. One way to address this challenge is through community asset mapping. This research approach offers a way to make youth more aware of and feel more connected to their local cultural and natural environments. Exactly how the community mapping process unfolds takes a different shape in each setting, but the underlying philosophy is always the same: to allow communities, including youth, to express their knowledge and experience in relation to the local environment, and then document that information in some type of creative format. This is what we call a community map. It might represent an aspect of community space or of community values. The Environmental Youth Alliance is currently working with youth to create these community maps on topics like the youth-friendliness of parks and health services in their neighborhoods. Although these research projects are ongoing, their experiences have already produced one positive and important finding: community asset mapping is an exciting and interesting way for youth to gather information, and in the process, youth learn about and gain a sense of ownership of their home places. As such, community asset mapping offers a new way to involve youth in maintaining and building stronger, more sustainable communities.

Possible Strategies for Enhancing Community Engagement in Stewardship and Restoration of Large Scale Transboundary Ecosystems

Henriette Bastrup-Birk

European Commission, Brussels

Objective: At the GBEI Steering Committee Meeting in May 2002, the need for greater community engagement in planning and implementation of action was emphasized.

As the Initiative aims at preserving and restoring a transboundary ecosystem, possible strategies for enhancing community engagement in such tasks across the international border will be examined.

General methodology: Mainly drawing upon European examples, alternative strategies will be presented and compared. An additional, experimental strategy, involving social learning through a cross-border pilot partnership of fieldworkers engaged in restoration and stewardship projects, will be laid out for discussion.

Results and significant conclusions: The feasibility, timeliness and acceptability, in the specific context of the Georgia Basin/Puget Sound region, of the different strategies presented, will be explored through an interactive discourse. Focus will be put on how best to ensure that Coast Salish Nations and Tribes play a key role in selecting and devising a preferred strategy and in setting the agenda for community-based action across the border.

Broader implications: The session will help establish the potential of the region to stand out as a showcase worldwide, combining social innovation and traditional ecological knowledge for the purpose of fostering stewardship and restoration of large-scale transboundary ecosystems.

The Shorekeeper's Guide for Monitoring Marine Intertidal Habitats

Glen S. Jamieson and Brian D. Smiley

Fisheries and Oceans Canada

With increasing interest in marine conservation and marine protected areas by the general public and special interest groups, there is a growing demand on resource management and environmental science agencies to actively solicit and incorporate citizen involvement in both habitat assessment and long term monitoring of marine resources. Intertidal ecosystem impacts typically relate to loss of habitat through infilling, substrate or beach slope alteration; increased sedimentation; alteration of freshwater discharges across the intertidal; biological changes resulting from trampling, removals or exotics; and introduction of chemical pollutants or physical structures. Point specific impacts are most amenable to management action.

Currently on Canada's West Coast, the challenge is to document intertidal impacts by technical training and co-ordination of community groups. Groups would be given defensible but practical methods to allow determination of whether or not indigenous marine ecosystems, and specifically their non-exploited renewable resources, are in fact being sustained. To meet the objective of obtaining detailed coastal resource information from trained non-professionals, Pacific Region researchers of Fisheries and Oceans Canada have developed and tested a sampling and training protocol published as the "Shorekeepers' Guide" for surveying intertidal habitats and associated biota in British Columbia. The overall goal is to produce data of sufficient quantity and quality for use by habitat managers, ocean planners and science researchers who are monitoring and assessing changes in marine communities. Here,

we briefly describe the Guide's mapping and surveying protocols and give an initial evaluation of data collected over the past five years, largely from Vancouver Island. We also discuss issues of field surveying, recruit training and data management that influence the reliability and utility of data provided by this protocol and others like it. The merits of biological decision-making frameworks such as the Index of Biotic Integrity that could use such citizen science data are explored in light of the nature of management authority currently given to marine resource managers.

Sound Stewardship—Using Citizen-based Restoration Monitoring as a Tool for Adaptive Management

Lisa Markovchick-Nicholls, Tom Dean, Phil Bloch, Jacques White

People For Puget Sound

Efforts to restore estuary wetland habitat in the region have been limited historically and suffered from poor public support. Challenges of restoring estuary wetlands in urban areas are amplified due to the small size and isolation of restoration parcels, and continued disturbance from development and invasive species. People For Puget Sound has developed a program to both encourage citizen adoption of restoration sites and to ensure adaptive management. By recruiting site stewards who report on the overall health of individual restoration sites on a monthly basis we are able to accurately track and remedy emerging problems such as trampling, desiccation, predation and debris removal. Intensive plant monitoring during the summer growing season is used to track and document the growth and composition of wetland and riparian vegetation, and identify invasive species problems. Annual monitoring is valuable for identifying and remedying flaws in site management and provide feedback on site design. Both types of monitoring play a critical role in helping site managers effectively respond to the needs of individual restoration sites. In addition to the benefits provided by economically monitoring and stewarding these sites, this program has resulted in a supportive constituency that understands the importance and challenges of restoring estuarine wetlands.

The Menzies Project—A Self-sustaining Citizen-based Monitoring Program

James G. Norris and Judy D'Amore

Marine Resources Consultants

The Menzies Project (www.menziesproject.org) is a partnership between the Port Townsend Marine Science Center and local research scientists. Its overall goal is to create a model for a scientifically sound citizen-based monitoring program supported by a sustainable funding source—the general public is invited for a fee to participate in collecting the data. It is named in honor of Archibald Menzies, naturalist onboard Vancouver's 1792 expedition to the Pacific Northwest. The research goal of the Menzies Project is to gather data on the marine environment that helps to fill gaps identified by other research scientists

and government officials. During the summer of 2002 we conducted 3-1/2-hour research cruises in Port Townsend Bay (two per day; four days per week) and 6-hour research cruises to Protection Island and Sequim Bay (one per day; two days per week). Monthly cruises were conducted during the remainder of the year with local 8th grade students. The following data were collected: physical oceanographic conditions (temperature, salinity, pH, dissolved oxygen, photosynthetically available radiation), plankton settled volumes and taxa present, underwater videographic observations, harbor seal counts, and shellfish counts and length frequencies (spot prawns and Dungeness crab).

Reefkeepers' Monitoring of Artificial Reefs: An Example of Local Citizen Science Involving Recreational Divers and Others on SE Vancouver Island

Brian Smiley

Fisheries and Oceans Canada, Pacific Region, Science Branch

Brenda Burd

Ecostat Research Ltd

In 1996, the Township of Sidney near Victoria on Vancouver Island built a 90m long waterfront pier for seascape viewing and recreational fishing. Regulatory agencies required the Township to provide compensation for habitat lost to the pier. Two artificial reefs using pre-formed concrete structures called Reefballs were constructed beside the pier to address this requirement, and also to promote community participation, sports diving and economic development. The pier and reefs attracted support from researchers, schools, media, developers and tourists alike, partly because this was the first application of such reef technology in northeast Pacific Ocean temperate waters.

To monitor the effectiveness of these artificial reefs, community leaders approached biologists at the Institute of Ocean Sciences, a local research facility of federal Department of Fisheries and Oceans. Without sufficient resources for such diver-intensive projects, the Institute began working collaboratively with the Royal British Columbia Museum and others to design and manage a project called Sidney Pier Artificial Reef Science (SPARS). This project involved volunteer time and in-kind contributions especially from specially trained recreational divers who conducted systematic surveys. Stemming from this local project is a broader DFO citizen science initiative called Reefkeepers that deals with subtidal monitoring protocols, information handling systems and community stewardship approaches. We report here on our recent interpretation of the SPARS dataset gathered from 1997 to 2001. Biases affecting data quality and utility are discussed here, as well as patterns of artificial reef colonization and recommended applications of such community-based science in coastal decision-making.

Session 7B: TRANSBOUNDARY AIR QUALITY (III)

Atmospheric Deposition in the Georgia Basin

Wayne Belzer

Environment Canada

The air we breathe is all around us, but very few toxic measurements have been made in the Georgia Basin. Environment Canada has accumulated data from several yearlong studies within this centre of B.C.'s population. Sampling and analyses include a wide variety of chemicals and substances. Some of these exceed guidelines. However, very little information exists for Canadian toxic pollutants in the ambient air. This presentation will show that there are seasonal and spatial variations in the Georgia Basin. Some of these pollutants can impact on acid deposition (aquatic and fish impacts), particle formation (health impacts) and overall air quality. Linkages between the atmosphere and the ecosystem impacts need to be addressed. This data is a start in the characterization of the Georgia Basin ecosystem.

Puget Sound Air Toxics

Naydene Maykut

Puget Sound Clean Air Agency

The Puget Sound Clean Air Agency conducted a study in 2002 in an effort to better understand the potential health risks to our three million residents from a group of air contaminants commonly referred to as air toxics. The study was intended to assist the agency in improving its air toxics regulations and voluntary programs and to provide more information for allocating resources. The study uses basic risk assessment concepts and models, such as toxicity and exposure assessment, to provide a general overview of the potential health impacts that could be due to air toxics. Because of limited resources, the authors did not perform comprehensive risk assessments, but used risk characterization techniques to estimate the relative impact of the evaluated toxic air pollutants. The primary health effect of concern from the chemicals evaluated in the study was cancer. The majority of the cancer risk estimated in the study is due to diesel soot. On average, diesel soot was estimated to account for 70 to 85 percent of the total cancer risk from air toxics in our area.

Long Range Transport of Pollutants to the West Coast of North America

Peter Schwarzhoff

Meteorological Service of Canada

Several research studies have demonstrated that Asian anthropogenic emissions significantly impact the concentration of a number of air pollutants measured in Western North America.

Other studies have indicated that this contribution to the "background" levels of air pollutants may rise, impacting

human and ecosystem health to a greater extent than at present. Clearly air management plans need to take these potential changes into account.

Results of a literature survey of long range transport measurements and mechanisms are summarized. The effects of Global Change are considered. Potential impacts on airshed management are discussed.

The Tao of Energy: Balancing Energy and the Environment in the Puget Sound/Georgia Basin BioSystem

Michelle L. Newman

University of Washington

Permitting Sumas Energy 2 after its second application in 2002 would have benefited the environment and the energy situation in the Puget Sound/Georgia Basin Region by contributing 660 megawatts of energy and resulting in more restrictive NO_x Best Available Control Technologies (BACT) for gas turbines in the US. The US has permitting processes pursuant to the Clean Air Act, such as Prevention of Significant Deterioration (PSD) and New Source Review (NSR), which are directly impacted by the BACT installed at each facility. Discussion will include the effects of existing gas-fired turbine in Sumas, Washington, on the downwind NO_x concentrations. Consideration of wind direction, wind speed data, and temperature will be made with respect to the dispersion of aerosol pollutants and resultant photochemical oxidants. With this data the impacts of the criteria aerosol pollutants on human health will be made with discussion of the US National Ambient Air Quality Standards (NAAQS).

Trend Analysis of Ground Level Ozone in the Greater Vancouver/Fraser Valley Area of British Columbia

Roxanne Vingarzan and Bill Taylor

Environment Canada

A multiple regression model incorporating meteorological parameters, annual cycles and random error due to serial correlation was used to investigate the 1985-2000 long-term ozone trend, both year round and during the summer (May-September), at five stations in the Greater Vancouver/Fraser Valley (GVRD/FV) area of southern British Columbia.

The study indicated that although average daily maximum ozone concentrations were relatively low compared to many urban areas of Canada, maximum levels, which typically occur during the summer, were similar to those measured in large urban centers in the Great Lakes-St. Lawrence corridor of southeastern Canada. Ozone levels were found to occasionally exceed the National Ambient Air Quality Objective, although these occurrences were relatively infrequent. The annual cycle of ozone was typical of areas influenced by both background and locally produced ozone, as indicated by the spring peak followed by elevated maxima occurring during summer months.

Trend analysis performed on the meteorologically adjusted

data found decreasing trends for summer ozone at all stations. Decreasing trends were also found for year round ozone for stations in the eastern portion of the study area, which are more greatly affected by locally produced ozone. These trends were consistent with local declines in ozone precursors and are in agreement with reported declines in summer ozone in urban areas of United States and Europe. In contrast, increasing trends were found for year round ozone at stations in the western portion of the study area, which, due to their geographical location, are less affected by locally produced ozone. There is some indication that increasing trends at sites in the western portion of the study area may be reflective of a global increase in background ozone levels. The results of this study suggest that ozone trends in the GVRD/Fraser Valley are in line with broad changes in ozone occurring in North America and Europe.

Session 7C:

PHYSICAL AND BIOLOGICAL OCEANOGRAPHY (II)

Determination of Local Biological Versus Advective Physical Processes and Their Resulting Effects on the Structure of Bio-Optical and Chemical Properties in Possession Sound Using a Network of Autonomous Seagliders

Julia K. Bos and Jan. A. Newton, Ph.D.

Washington State Dept. of Ecology

Charlie C. Eriksen, Ph.D.

University of Washington

The development of a small underwater glider equipped with sensors to measure temperature, salinity, dissolved oxygen and chlorophyll fluorescence, that moves autonomously through the water column and reports data in real time, allows for measurements of water properties in four dimensions. This work has been developed at the University of Washington Applied Physics Lab and is being tested collaboratively through a National Oceanographic Partnership Program grant to UW, the Washington Department of Ecology, and other agency and industry partners.

A network of gliders was deployed in Possession Sound during July, 2002. We have calibrated the data gained by these gliders and, using information generated by this deployment, can begin to ascertain the impact of advective processes in contrast to local biological processes on the structure of biological and chemical properties in this area. We describe results from the gliders and their in-situ sensors, our methods used to calibrate the data generated, and preliminary work to differentiate between biological and advective effects on the measured water properties.

***In Situ* and Remote Monitoring of Water Quality in South Puget Sound: The ORCA Time Series**

Wendi Ruef, Allan Devol and Steven Emerson

University of Washington

John Dunne

Princeton University

Jan Newton, Rick Reynolds and Julia Lynton

University of Washington

We obtained high frequency measurements of chemical, physical, and biological properties throughout the water column at a fixed station using an autonomous moored profiling system in south Puget Sound, a largely undeveloped area subject to extensive future urbanization and potentially sensitive to impacts from eutrophication. Measurements were taken every two to six hours for over two years using surface meteorological sensors and a profiling underwater instrument package consisting of a Seabird CTD, dissolved oxygen electrode, Wetlabs transmissometer and chlorophyll fluorometer.

The data set reveals strong seasonal forcing in surface temperature and salinity, producing frequent intermittent periods of either strong stratification or deep mixing throughout the summer. Oxygen saturation varied from under-saturation (~60%) at all depths during the winter, to mid-summer values near saturation (~90-100%) at depth and supersaturated (~150%) at the surface. Chlorophyll and oxygen co-varied, with the chlorophyll maximum moving subsurface after the spring bloom. A box model using the data set to estimate net biological oxygen production gave values of net community carbon production that were significantly lower than the carbon fixation determined by ¹⁴C incubation measurements.

Circulation Variations in the Strait of Juan de Fuca

Glenn A. Cannon

University of Washington

The Strait of Juan de Fuca is a fjord estuary connecting Puget Sound and the Strait of Georgia to the Pacific Ocean. This paper reviews large-scale observations of circulation that are important for interpretation of smaller scale studies both in space and time.

Circulation in the Strait is tidal with a superimposed estuarine circulation that is seaward at the surface and landward at depth. Coastal storms cause flow reversals lasting from a few days to more than a week. Southerly winds push water against Vancouver Island reversing the sea-surface slope in the Strait. This results in landward intrusion of fresher, warmer surface water and seaward retreat of deep saltier water. Reversals can occur throughout the entire inner Strait and extend across the continental shelf through the Juan de Fuca Canyon. Coastal changes also can affect salinity at the entrance sill into Puget Sound,

that in turn affects bottom water intrusions into the Sound. Thus, circulation within the Strait and between the Strait and the Pacific Ocean can have large variations that in many cases exceed the mean. These variations could greatly alias interpretation of sampling of water properties and organisms on relatively smaller space and time scales.

Pulsed Replenishment of Water Properties and Dissolved Oxygen in Hylebos Waterway, Tacoma, Washington

Jeff Cox

Evans-Hamilton, Inc.

Teri Floyd

Floyd Snider McCarthy, Inc.

An extensive study of the circulation and water replenishment characteristics of Hylebos Waterway, located within the Port of Tacoma, Washington, was conducted as part of an overall study of the quantity, location, and influence of wood debris in the head of the waterway. A combination of current, water property, water quality, and meteorological measurements, along with information on ship movements provided extensive insight into the temporal and spatial variations in the water properties, and in particular dissolved oxygen conditions, along the waterway. We discovered the waterway has a flushing and replenishment system not seen previously elsewhere in Puget Sound so clearly.

Circulation and water replenishment in the head of the waterway occurs on a pulsed rather than a continuous basis. Pulse rates of the arrival to the head of the waterway of batches of replenishment water occurred at approximately three to five day intervals, between which occurred periods of stagnation. This pulsed nature of the circulation appeared to be driven by a complex combination of spring vs. neap tides, thickness of the freshwater lens from the Puyallup River when it lay off the mouth of the waterway, freshwater thickness directly entering the head of the waterway, and the density structure of the waterway's old water. The pulsed nature of the circulation occurred in all seasons, though seasonal variations in its strength were evident. Newly arriving marine water traveled along the waterway bed and displaced old water upward when entering the head, from which the old water began its travel seaward towards Commencement Bay.

Understanding the circulation and water replenishment proved critical to understanding the sources, sinks, and use rates of dissolved oxygen within this system, which allowed the true effects of wood debris upon dissolved oxygen within the water column to be understood properly.

On the Origin of Harmful Algal Bloom Species in Pacific Coast Estuaries: Perspectives from ORHAB

Katherine M. Cox, Jan A. Newton and Julia Bos

Washington State Department of Ecology

Ecology is a partner in the NOAA-sponsored Olympic Region Harmful Algal Bloom (ORHAB) project. ORHAB is a joint effort including federal, state, tribal, private, and academic partners to understand the processes that cause harmful algal blooms (HABs) both offshore and within our coastal estuaries. Ecology's role within this project is to understand the HAB connection between coastal estuaries and adjacent coastal waters: to identify whether the coastal areas are acting in unison or independently. Our goal is to understand whether HAB events within Willapa Bay are imported from the coastal ocean waters under specific conditions or originate from endemic populations within the bay. This is important because different monitoring and management strategies would be indicated.

To evaluate this, we are comparing hydrographic, nutrient and phytoplankton data from Bay Center in Willapa Bay and numerous locations from the outer coast. Our preliminary data from 2002 have shown a connection between higher salinity, colder water at the Bay Center mooring site and increased numbers of diatoms at the same location, although dinoflagellates do not show this pattern. We are exploring the possibility that an influx of ocean water into the estuary is the cause of some, but probably not all, toxic algal blooms.

Observations and Simulation of seasonal variability within the Straits of Georgia and Juan de Fuca

Diane Masson and Patrick F. Cummins

Institute of Ocean Sciences

The Strait of Georgia is a large semi-enclosed estuary on the southern coast of British Columbia. The main connection to the Pacific is to the south, through Juan de Fuca Strait. Abundant freshwater discharge, mainly from the Fraser River, forces a two-way exchange with oceanic shelf water. The resulting circulation is forced by tides, wind stress, and freshwater discharge. Both the coastal wind stress and the flux of freshwater are subject to strong seasonal modulations, producing a marked seasonal cycle in the water properties of the region.

Several time series of extended length have been examined in terms of the seasonal response and results are compared with output from numerical simulations with the Princeton Ocean Model (POM). The model, forced with tides, seasonal wind stress and freshwater discharge, is integrated over several years until the system approaches statistical equilibrium. The results show good agreement with observations from Juan de Fuca Strait, as well as over the upper part of the water column within the Strait of Georgia. However, simulation of the seasonal cycle of the deeper water in the Strait of Georgia is more problematic.

The deep water properties apparently are determined by a complex balance between dense intrusions from the sill area and local vertical mixing.

Session 7D—Panel : MODELING ALTERNATIVE FUTURES FOR THE CHICO WATERSHED

Assembling and Presenting Watershed Process Models for Evaluating Future Land Use Scenarios

Paul Nelson

Kitsap County Planning

Cumulative affects associated with sprawl-type development patterns are overwhelming water quality and aquatic and terrestrial habitat protection efforts. Effective aquatic resource protection and restoration efforts will need to be planned at the watershed-scale. The Chico watershed is one of Kitsap County's most productive salmon bearing streams. Without adequate assessment and planning, the environmental infrastructure of such watersheds (i.e. stream-sides, estuaries, floodplains, fish rearing habitats, etc.) is usually severely degraded.

The *Alternative Futures Approach* includes the systematic assessment, design, and evaluation of future land and water use scenarios for a particular geographic area/ watershed. The approach is intended to help local governments simplify the task of integrating numerous land use planning and aquatic and terrestrial habitat protection objectives (per CWA, ESA, Growth Management Act, Shoreline Management Act revisions, etc...) into a more coherent and technically grounded vision of the future of the watershed. The approach provides a watershed-based and community accessible framework without being prescriptive.

In the Chico watershed, water quality, water quantity, aquatic terrestrial habitat protection, and community infrastructure investment priorities will be evaluated across a range of future land use scenarios. The panel will present the range of technical analysis that were used in the Chico pilot project to help define the types of information and analysis available to local jurisdictions attempting to develop smarter growth and development patterns, resulting in more effective watershed protection and restoration efforts.

Hydrologic and Riparian Processes within the Chico Watershed

Mindy Roberts

University of Washington, Watershed Science Center

Comparing and Evaluating Rapid Assessment Techniques of Stream-Channel Conditions for Assessing the Quality of Aquatic Habitat at the Watershed Scale

Catalina Segura-Sossa and Derek Booth,

University of Washington, Watershed Science Center

Michael Rylko

U.S. Environmental Protection Agency

Paul Nelson

Kitsap County Planning

Assessing stream-channel process, structure, and function is a fundamental goal of any watershed evaluation. Yet such assessments are difficult for local entities to design and carry out effectively for several reasons:

- Limited time, which normally requires that stream “structure” is the sole attribute to be measured, with correlations to process and function defined or (more commonly) just assumed.
- Limited scientific resources, which makes a defensible assessment difficult to design.
- Limited field-staff resources, which makes systematic coverage of the number of stream miles in a given jurisdiction or watershed a daunting task, particularly for detailed or highly quantitative measurement protocols.

While fully quantitative approaches may provide an apparent benefit through their high precision and documentation, they are of limited value if the institutional resources simply do not exist to carry them out. Repeatability of results across multiple observers is also commonly much poorer than the apparent precision of the raw data might suggest. Finally, management actions commonly occur on a very coarse scale—the range of options is often limited, and even where a high degree of discrimination between different levels of condition might be achieved, the management response to many of those potential outcomes might be identical. As a result, rapid assessment techniques that can cover a channel network rapidly (on the order of miles per day) may provide nearly equivalent benefit to land managers as laborious survey-based techniques, particularly if the rapid approach is calibrated and tested against more precise methods.

To evaluate the current and alternative future conditions of stream channels in the Chico Creek watershed (central Kitsap County), stream channel assessments were conducted in 2001 and 2002 using cooperative field teams that used rapid techniques to assess the condition of the stream channels. Each methodology was based on four categorical evaluations of channel geomorphology. The “rapid 1” assessment included channel stability, reach complexity, riparian conditions, and cementation, and the “rapid 2” method followed a protocol first articulated by Scholz and Booth (2001) and further refined by McBride (2001) that emphasized sediment quality and channel-bank erosion, together with tallies by reach of pools, and large woody debris (LWD). The results achieved with each methodology

were evaluated using detailed quantitative measurements that include surveyed profiles, cross sections, wood counts, and pebble counts, together with estimates of LWD recruitment potential developed from spatial analysis in GIS.

Forty-one stream reaches of about 1000 ft each, covering 7 miles of channel in total, were assessed independently by both methods using different field crews. In general, both methodologies give similar results. At 36 reaches the difference between total scores on a 16-point scale was less than 3. The largest discrepancies appeared at channel gradients higher than 2%, corresponding to the typical shift from predominantly pool-riffle to typically plane bed and step pool channel morphology. At the level of individual metric in each methodology, channel cementation (common to both schemes) showed statistically different results between the two sets of observers. Bank stability, large woody debris, and pools used in the “rapid 2” gave comparable results to channel stability and complexity measured with the “rapid 1” method.

The comparison of these two rapid techniques with the detailed surveying corroborated the findings of ambiguous, highly variable results for cementation. It also showed that rapid LWD counts are a reliable measurement. The riparian condition score, used only by the “rapid 1” as an in-stream estimated of corridor vegetation density, showed no relationship with the LWD recruitment potential from GIS.

Based on these results, we believe that rapid assessment methods are justified wherever a limited number of options are being considered. For many jurisdictions, the overriding need is for identifying a few general categories of stream condition; typically, the management responses will be to protect those streams that are properly functioning, to maintain and/or rehabilitate those that are showing some signs of impairment, and to simply acknowledge the need for intensive remedial actions for those that are already significantly degraded by human action. Where intensive rehabilitation work is planned, detailed quantitative assessments ultimately will be needed. To include such measurements as part of a preliminary regional assessment, however, makes little sense. Although, rapid assessments are entirely adequate to determinate general stream condition categories, some awareness should be given to: (1) the inclusion of variables, such as cementation that cannot be replicate and (2) the inclusion of categorical scores that may required specialized training. Such is the case for bank stability (used in the “rapid 2” technique) and channel stability and reach complexity (used in the “rapid 1” method). For the later, LWD and pool counts provide a better alternative, particularly if time or funds for training are minimal.

Evaluating the Effects of Human Development Patterns on Terrestrial Habitat Function

Mary Linders and George Wilhere

Washington Department of Fish and Wildlife

To inform the process of local land-use planning 3 future development scenarios (planned trend, conservation, and

moderate alternatives) were evaluated for their effects on terrestrial wildlife habitat. Land cover was mapped from existing sources; 12 land-cover and 3 stream-channel classes were used to depict habitat conditions in the watershed. Future landscape condition was modeled by assigning "footprints" to undeveloped parcels based on zoning density and lot size. Assumptions focused on how different land use patterns affect forest seral-stage. Wildlife-habitat relationship models were constructed for 9 species including the red-legged frog, western toad, Douglas squirrel, bobcat, downy woodpecker, pileated woodpecker, willow flycatcher, blue grouse, and great blue heron. Habitat quality was evaluated based on vegetation type, patch configuration, and home-range size. Species models were run on current and future land covers. Landscape changes that applied to nearly all species under the planned trend include: 1) a decrease in the total amount of habitat available; 2) an increase in fragmentation (i.e. an increase in the number of patches with a corresponding decrease in patch size); and 3) an overall decrease in habitat quality, with consistent loss of primary breeding and foraging habitats. Landscape changes under the conservation alternative were intermediate between current conditions and the planned trend. The moderate alternative uses the concepts of large blocks of land and wildlife corridors to mitigate the effects of planned trend development.

Evaluating the Implications of Watershed Change on Stream Conditions and Salmon Habitat

Paul Nelson

Kitsap County Planning

Watersheds and stream channels are formed by erosional and depositional processes, which are driven by climatic, geologic and vegetative patterns over time. These processes are naturally dynamic. Channel form and riparian conditions are examples of in-stream characteristics that can be observed to define how well a watershed is functioning. The parameters considered in this analysis are grouped into six major elements: habitat, habitat access, watershed condition (sediment, water, and LWD inputs), channel condition (channel stability, complexity, cementation), hydrology, and water quality. The status of each major element is determined by assessing the condition of a number of indicators. Well accepted criteria were used to class indicators as properly functioning, at risk, or not properly functioning.

The combined effects of land use change, road construction and forest harvest have left their mark on the morphology of the Chico watershed stream network. Where development has occurred, the creek is usually disconnected from its floodplain. These reaches are entrenched, have unstable banks, have reached some level of cementation and usually are surrounded by an immature, narrow riparian corridor that includes a variety of exotic and invasive vegetation. Culverts and bridges have inhibited the natural movement of sediment and large woody debris, creating localized areas

of material excess and starvation. However, where forested lands still remain, and riparian corridors are being managed, the creeks seem to be recovering from past disturbance and functioning stream reaches provide us with reference conditions for this watershed.

The future of these stream reaches will be determined, in large part, by the management and use of the land within the local drainages. This project assessed the likely future impacts to the stream channels and aquatic habitat associated with different land use and development scenarios. The Plan Trend scenario showed high levels of impact while more moderated development scenarios were shown to have much less potential impact to the streams and aquatic habitat within the Chico watershed. In all scenarios, specific restoration efforts were identified as necessary to stabilize or recover key reaches within the watershed.

Session 7E: ORCAS ON THE ROAD TO RECOVERY: CHALLENGES AND OPPORTUNITIES FOR INTERNATIONAL COOPERATION

Both government and non-government organizations need to act now if the decline in orca population is to be turned around. As the orca's key habitat extends across national boundaries so must the response. As precedents with other species have established transboundary management, so should the orca recovery strategy. Panelists will describe challenges, opportunities and priorities for developing a successful recovery partnership.

- **Marilyn Joyce**, Fisheries and Oceans Canada, Marine Mammal Coordinator for the Pacific Region
- **Fred Felleman**, Orca Conservancy
- **Brent Norberg**, Marine Mammal Coordinator, National Marine Fisheries Service (NMFS), Northwest Region
- **Peter Ross**, Institute of Ocean Sciences
- **Susan Berta**, Orca Network
- **Marc Pakenham**, Executive Director of Veins of Life Watershed Society

Session 7F—Workshop BRITISH COLUMBIA/ WASHINGTON ENVIRONMENTAL COOPERATION COUNCIL MEETING (CONTINUED)

Session 8A: MARINE CONSERVATION

Species of Concern in the Georgia Basin/Puget Sound Marine Ecosystem: More Support for a Transboundary Ecosystem Approach to Marine Conservation

Joseph K. Gaydos and Kirsten V.K. Gilardi

U.C. Davis School of Veterinary Medicine

Species of concern are native plants and animals that warrant special attention to ensure their conservation. Within the inland waters of Washington and British Columbia, the Canadian Federal Government, the United States Federal Government, Washington State, and the province of British Columbia each have different processes for assessing which species require special initiatives to ensure protection and survival of the population. We evaluated listings from all four jurisdictions and identified a total of 60 species from the shared Georgia Basin / Puget Sound marine ecosystem that were listed as species of concern (current on September 1, 2002). Each jurisdiction underestimated the number of species of concern within the entire marine ecosystem: Washington State identified 73%, the Province of British Columbia identified 47%, the Canadian Federal Government identified 38%, and the U.S. Federal Government identified 30%. Acknowledging that species abundance and distribution differ within the ecosystem and listing criteria differ by jurisdiction, recognition of species of concern on an ecosystem basis gives a more complete perspective on the health of our shared marine ecosystem. We propose that the identification of 60 species of concern may be indicative of ecosystem decay. Efforts need to be continued to identify shared species of concern and plan their recovery on an ecosystem basis.

Ecoregional Conservation Planning in the Marine Environment

Mary Lou Mills and Brian MacDonald

Washington Department of Fish and Wildlife

The Washington Department of Fish and Wildlife (WDFW) has identified a need for large-scale planning that will lead to effective and efficient conservation of the state's fish and wildlife. WDFW is working closely with The Nature Conservancy (TNC) on ecoregional conservation planning to conserve biological diversity via the construction of a network of "conservation sites" that, if properly managed, should conserve most of an ecoregion's biological diversity in a cost-efficient manner (a minimum set of reserves). The process is data intensive. Data are compiled for both coarse filter (communities) and fine filter (species) targets including: known locations of occurrences, land cover maps, habitat maps, land ownership, and other spatial data.

To help support this process we are assembling a centralized database containing the biological and environmental information collected from numerous

datasets located within the Marine Resources Unit (MRU) in WDFW. Historically, many of these datasets have resided only on the desktop PC's and in the notebooks of biologists and resource managers. This exercise has not only allowed us to provide relevant information to the ECP process, but has also helped to establish a framework within the MRU to share data across projects.

Toward a National Marine Conservation Area in the Southern Strait of Georgia

William D. Henwood

Parks Canada

Parks Canada is committed to creating a system of National Marine Conservation Areas (NMCA) through the establishment of one NMCA in each of the 29 marine regions that have been identified in Canada's three oceans and the Great Lakes. Of these 29 regions, five occur on the Pacific coast: Hecate Strait, the Queen Charlotte Islands Shelf, Queen Charlotte Sound, the Vancouver Island Shelf and the Strait of Georgia. Parks Canada, in partnership with British Columbia and Fisheries and Oceans Canada, is now proceeding with studies to assess the feasibility of establishing NMCAs in two of these regions, adjacent to Gwaii Haanas National Park Reserve in the Queen Charlotte Islands Shelf and Hecate Strait regions and in the southern Strait of Georgia, adjacent to the proposed national park in the southern Gulf Islands.

The purpose of the feasibility study is to determine whether or not the establishment of the proposed NMCA in the southern Strait of Georgia is practical and desirable, both from a policy perspective and in terms of public support. The assessment of feasibility must determine, on the one hand, whether the establishment and management of a NMCA in the southern Strait of Georgia, with a particular boundary configuration, can reasonably be expected to achieve the objectives prescribed for it. These objectives will be defined by both Parks Canada's policies with respect to the establishment and management of NMCAs and by the aspirations of other federal and provincial government agencies, municipal and regional governments, First Nations, stakeholders and local residents. Aided by an effective communications plan, and both broad and narrowly focussed consultations, the feasibility study must also determine whether there is sufficient public support to proceed with NMCA establishment. This paper will explore the planning framework being proposed for the feasibility study and its expected outcomes.

Achieving a System of Marine Protected Areas in the Northwest Straits Region of Washington State: A Nearshore Perspective

Kate Smukler

NOAA Marine Protected Areas Center

Marine Protected Areas (MPAs) have increasingly been recognized as a tool to manage and help protect fragile marine ecosystems. Systems or networks of MPAs may provide more effective protection for the diversity of species

and their life history stages than single, isolated MPAs. The Northwest Straits Marine Conservation Initiative in Washington State has a mandate to “achieve a scientifically-based, regional system of MPAs.” This will be achieved through local marine resources committees (MRCs) in each of the seven counties along the Northwest Straits organized by the Northwest Straits Commission. The 107 documented MPAs, offering varying degrees of protection, have been established in this region by federal and state agencies, local governments, and private organizations. Most were established independently, and were not intended or designed to function as a network. Using the ShoreZone Inventory developed by the Washington Department of Natural Resources (WDNR), habitat characteristics along the shoreline of each MPA were examined and mapped. The degree to which each regional habitat type was represented in existing MPAs was evaluated within both partially and fully protected MPAs. Representativeness has been identified as a criterion in MPA network design when the goal is to protect biodiversity, and has been utilized in the planning processes. This preliminary analysis of the functionality of a de facto MPA network is an example of a tool to improve the use of MPA networks in protecting marine biodiversity in the Northwest Straits region of Washington State, and may serve as a national model for MPA network development.

Session 8B: LOW IMPACT DEVELOPMENT APPROACHES AND WATERSHED HYDROLOGY

Management Strategies for Urban Stream Rehabilitation in the Pacific Northwest

**Derek B. Booth, James R. Karr, Christopher P. Konrad,
Sally Schauman, Sarah A. Morley, Marit G. Larson and
Stephen J. Burges**

University of Washington

Physical, hydrological, social, and biological conditions were evaluated at 45 stream sites in the Puget Lowland of western Washington with urban development as their dominant human activity. Using the benthic index of biotic integrity (B-IBI) as our biological indicator, we found a progressive decline in B-IBI with increasing watershed imperviousness but with large site-to-site differences at any given level of imperviousness in the contributing watershed. This variability is greatest at low to moderate levels of development; no threshold effects are apparent. Instream biological condition also varied directly with a new stream flow metric, showing significantly better correlations than with imperviousness. We also found a wide range of landscape conditions, some very degrading, in the backyards adjacent to these streams. These data do not suggest that the full range of ecological conditions can be replaced in a now-degraded urban channel; thus key management tasks are to identify those watersheds where low urbanization and associated high-quality

stream conditions warrant protection, and to develop new management goals for those watersheds whose surrounding development precludes complete ecosystem restoration but in which some recovery might be possible. There is no rational basis to support a common strategy in all watersheds, developed and undeveloped alike.

East Clayton Stormwater Infiltration Systems Design and Predicted Operation

J. Dumont

McElhanney Consulting Services Ltd

The East Clayton Neighbourhood Concept Plan includes land use and planning concepts, development guidelines as well as servicing and financing plans for a new 250-hectare neighbourhood within the City of Surrey. The Plan calls for the use of innovative storm water management. The Plan is a policy framework with specific performance targets to guide the development of this sustainable community. The City of Surrey has partnered with senior government agencies and developers in building a large pilot development.

The Plan calls for stormwater infiltration systems to maintain the hydrologic regime in its predevelopment form. This requires the use of stormwater infiltration systems to match the runoff pre-development and post-development hydrographs. Designing these systems required innovative techniques to predict and optimize their performance in some very difficult terrain with high groundwater and low infiltration rates.

The infiltration systems designed using conventional techniques using individual design storms resulted in very promising results. The operational characteristics were then tested using continuous simulations using long term, multiple year (1962 through 1998) rainfall records. Several modifications were required to optimize the systems while identifying performance limitations. The first phase of development has been constructed and the operation of the stormwater systems will be monitored to verify their performance.

Accelerated Program to Identify County's Urgent Drainage Needs

Gregg Farris

Snohomish County Surface Water Management Division

Steve Swenson

R. W. Beck, Inc.

John Rogers, P.E.

CH2M HILL

In less than two years, Snohomish County staff and two multidisciplinary consultant teams conducted an ambitious program to identify flooding, habitat, water quality and erosion problems and solutions within nearly all of the Urban Growth Areas (UGAs) in the County. This work will help guide decision making for the implementation of flooding prevention, habitat protection and enhancement,

and other drainage-related community benefits in the areas of the County that have experienced, and will continue to experience, the most growth. Due to the size of the project, known as the Drainage Needs Report (DNR) project, the roughly 60-square-mile study area was divided into 11 individual study areas and watersheds. The analyses relied on an integration of high-accuracy GPS inventory data, GIS technology, stream and wetland habitat surveys, and detailed hydrologic and hydraulic modeling. Due to the magnitude of effort and the aggressive schedule for this project, the individual study areas were analyzed concurrently by a total of 13 consulting firms and County staff. The main products of this project included a list of recommended surface water projects with preliminary designs, an accurate inventory of existing drainage systems, and hydrologic and hydraulic models for many of the major conveyance systems.

WSU Pierce County Low Impact Development Pilot Project Monitoring

Curtis Hinman

WSU Cooperative Extension, Pierce County

Pierce County is examining the application of new Low Impact Development (LID) guidelines to more effectively manage stormwater and protect streams, lakes and wetlands. Public and private partners in this effort are currently designing the first LID residential project in the Puget Sound region with construction scheduled to begin summer 2003.

The 8.27-acre site, located in northern Pierce County, is representative of the challenging soil conditions in the region and is bordered by a salmon bearing stream. The project will incorporate cluster design with accessible open space, rain gardens, porous surfaces, minimal excavation pin foundations, native vegetation and soil restoration, enhanced stream buffer systems, and other small-scale, dispersed stormwater controls. The central goals will be to design an integrated LID system that more closely mimics native hydrologic function to protect adjacent stream values, enhance groundwater recharge, as well as construct an affordable and livable neighborhood.

Research investigating the stormwater management characteristics of bioretention, soil enhancement, and other LID practices that are integrated into a stormwater management system does not exist for this region. Monitoring the performance of the Pierce County pilot project provides a tremendous opportunity to determine the appropriate guidelines for the application of LID in the Puget Sound region. The primary goal for the monitoring program is to assess the performance of individual LID practices and evaluate the effectiveness of integrating these practices to more closely mimic pre-development hydrology.

Currently, pre-construction monitoring equipment has been installed and data collection is in progress. The presentation will focus on the process for implementing LID in Pierce

County and the Puget Sound region, as well as the project and monitoring design.

In the Absence of Standards Low Impact Development Might Equate to High Impact Development

Thomas W. Holz, PE

SCA Consulting Group

The low impact development (LID) concept is a good beginning for much needed change in the way we develop land. LID, as a concept, describes a collection of goals and practices that might protect streams if watersheds were developed employing the practices described.

However, the concept is not practical or useful until is refined into a set of standards that are then adopted into municipal code. The translation of concept into municipal code presents much opportunity for subjectivity. For example, is cluster development compatible with LID? How many units per acre can be placed before exceeding thresholds? Is a short wide driveway equivalent to a long narrow one with the same impervious area? Are strict fire ratings for structures part of LID code?

We have nearly a century of experience in writing standards for traditional urban landscapes. Many of the standards in code today have been refined through trial and error (many trials and many errors). Erosion control protection standards, for example, are still a work in progress. But we have no similar experience with LID standards. Faced with the last chance at preserving watersheds in the path of development, how should standards be crafted?

Stormwater Runoff Flow Control Benefits of Urban Drainage System Reconstruction According to Natural Principles

Richard R. Horner

University of Washington

Seattle Public Utilities constructed two drainage projects to decrease stormwater quantities discharged to Pipers Creek, with the goal of reducing channel erosion and pollutant loadings. The Viewlands "Cascade" replaced a narrow ditch with a wide series of stepped pools. Reconstruction of 200 meters of 2nd Avenue NW and its drainage system reduced impervious area and provided vegetated stormwater detention areas. At both sites flow has been continuously monitored in relation to precipitation to determine actual benefits. The Viewlands Cascade is capable of reducing the influent runoff volume by over one-third during the wetter months and overall for the year. Relative to estimates for the preceding ditch, the new channel reduces runoff discharged to Pipers Creek in the wet months by a factor of three. The 2nd Avenue NW project has prevented the discharge of all dry season flow and 98 percent of the wet season runoff. It can fully attenuate the runoff volume produced by approximately 19 mm of rain on its catchment. Relative to estimates for a conventional street design, the

alternative reduces runoff discharged to Pipers Creek in the wet months by a factor of 4.7. The results demonstrate that “naturalizing” urban drainage systems can yield substantial benefits.

Session 8C: INVASIVE SPECIES

Ecological Monitoring of Introduced Species in Douglas Fir Forest Ecosystems on Southern Vancouver Island in the Georgia Basin

Jennifer Bailey and William T. Dushenko

Royal Roads University

Introduced species were inventoried and the effect on community biological diversity was examined in selected forested sites at Royal Roads University. The sites occur within the endangered Coastal Douglas-fir biogeoclimatic zone on southern Vancouver Island. Two long-term 1-ha study plots were established along the forest periphery, in areas of human activity. Four modified 20 m² plots were also established in the relatively undisturbed interior forest for comparison and a 1-ha plot at Rocky Point was used as a control site. Percent cover of ground vegetation species was determined within 128 randomly placed 1 m² permanent vegetation plots nested within the study sites. A significant positive correlation was found between biological diversity (Shannon index) and percent introduced species. The presence of introduced species was also significantly greater within the periphery plots, with the greatest presence found along the disturbed edges of up to 81% cover on average. Dominant introduced species included *Daphne laureola*, *Agrostis capillaries*, and *Holcus lanatus*. Introduced species were also detected in the interior forest sites (average 3.4% cover), which suggest the need for a more effective invasive species management plan. The broader implications of introduced species invasion with respect to ecosystem management issues and restoration initiatives are discussed.

Effects of Temperature and Salinity on Larval Growth Rates and Dispersal Potential of the Introduced Bivalve, the Varnish Clam (*Nuttallia obscurata*), in Coastal British Columbia

Sarah E. Dudas, John F. Dower and Theresa Peters

University of Victoria

We determined the influence of temperature and salinity on larval varnish clam growth rates, in order to establish the tolerance levels of this recently introduced species. Adult varnish clams were spawned in the laboratory during their natural reproductive season and the larvae reared at 9, 15 and 20°C and 10, 15 and 20 ppt. Shell growth was measured twice weekly until the larvae either metamorphosed or died. The highest growth rates occurred in the 20°C and 20 ppt treatments. Time-to-metamorphosis ranged from three to eight weeks, with higher temperatures

and salinities resulting in a shorter planktonic phase. Larvae reared at 9°C, 10 and 15 ppt grew slowly and survived for a minimum of one month but did not reach metamorphosis. These results indicate that varnish clam larvae have a wide range of salinity and temperature tolerances, but grow optimally at warmer temperatures and higher salinities. The high variability in time-to-metamorphosis, and the potentially long planktonic phase, has important implications for dispersal and geographical range expansion in the Georgia Basin and Puget Sound.

Linking Control Data With Basic Ecological Information To Improve The Removal Efficacy Of The Invasive Cordgrass, *Spartina anglica*, in Puget Sound, WA

Sally D. Hacker and Tabitha G. Reeder

Washington State University Vancouver

Megan N. Dethier

University of Washington

The nonindigenous cordgrass, *Spartina anglica*, covers ~3,000 ha in Puget Sound, causing changes to invaded intertidal communities. A control program, begun in 1997, has caused a ~20% decline. We combine control data with basic ecological information and determine three main factors influencing control success. First, number of years and consistency of removal are critical. After four years, sites with consistent control (uninterrupted for ≥ 2 years) showed 86% ($\pm 5\%$) decline, 2.5 times greater than those with intermittent removal (≥ 1 year missed; $32 \pm 6\%$). This was true even though the number of years between control regimes varied by ≤ 1 year. Second, control success differed among habitat types. Low salinity marshes have smaller declines ($13 \pm 4\%$) compared to mudflats ($38 \pm 5\%$) and cobble beaches ($34 \pm 4\%$) while high salinity marshes show the best response ($45 \pm 5\%$). These differences probably originate from responses of both *S. anglica* and native competitors to different physical conditions rather than years of removal. Third, spatial scale is important; larger invasions (>10 ha) had a lower percent decline ($39 \pm 8\%$) than smaller (≤ 10 ha) invasions ($66 \pm 6\%$) suggesting that more extensive invasions show better regrowth.

Pathways and Regulation of Aquatic Nuisance Species into British Columbia's Waterways

PG Lim

Fisheries and Oceans

Aquatic nuisance species are of concern in British Columbia not only because of the extent of the province's marine coastline, but also because of the large network of freshwater lakes and rivers which support commercially important species. There are numerous pathways of introduction of nuisance species into British Columbia's aquatic systems. These include ballast water, the pet and aquarium trade, live seafood and transportation of pleasure boats from the Great Lakes area. There is limited documentation of the status of aquatic nuisance populations in the province. European Green Crab (*Carcinus maenas*),

Zebra Mussels (*Dreissena polymorpha*), Eurasian Water Milfoil (*Myriophyllum spicatum*), Purple Loosestrife (*Lythrum salicaria*), Common Carp (*Cyprinus carpio*) and Spartina (*Spartina alterniflora*) are among the nuisance species that have been observed in British Columbia.

Review of federal and provincial legislation which are applicable to limiting the intentional introduction of aquatic nuisance species shows that many regulatory gaps exist. For example, Schedule VIII, Section 5 of the Pacific Fisheries Regulations of the Canada Fisheries Act provides a list of prohibited live fish for importation. The adequacy of this list for the purpose of preventing the importation of species that might threaten local indigenous species needs to be examined. Present knowledge of aquatic nuisance species and their pathways of introduction provide a basis for updating some of these regulations.

Interjurisdictional Responses to Aquatic Nuisance Species in the Pacific Northwest

Stephen Phillips

Pacific States Marine Fisheries Commission

Mark Sytsma

Center for Lakes and Reservoirs

Authorized by Congress in 1947, the Pacific States Marine Fisheries Commission (PSMFC) is one of three interstate commissions dedicated to resolving fishery issues. Representing California, Oregon, Washington, Idaho, and Alaska, the PSMFC does not have regulatory or management authority; rather it serves as a forum for discussion, and works for coastwide consensus to state and federal authorities.

The objective of our ANS prevention/education program is to prevent harm from ANS species to important commercial and recreational fisheries and the ecosystems upon which these fish depend.

Currently, the program funds are directed at four species: zebra mussels, Atlantic salmon, green crab and mitten crab. Program emphasis is on outreach and education to appropriate user groups. Zebra mussel (*Dreissena polymorpha*) prevention has focused on educational outreach to boaters, monitoring for zebra mussel presence, and the establishment of a zebra mussel hotline in the western United States.

Program funds are also being used to determine abundance and distribution of European green crab (*Carcinus maenas*), Atlantic salmon (*Salmo salar*) and Chinese mitten crab (*Eriocheir sinensis*) in selected West Coast locations. Research at Portland State University is focused on developing a model that will provide a basis to predict the potential range and population size for Chinese mitten crabs in these specific estuaries.

Session 8D: STEWARDSHIP-COMMUNITY APPROACHES (II)

Carrot, Not Sticks: Harnessing the Local Economy and Using Incentives to Protect Natural Areas in the Southern Gulf Islands

Linda Adams

Islands Trust

This presentation will focus on the use of voluntary and incentive-based tools to protect the natural environment of the islands in the Georgia Basin. It will demonstrate how such tools can result in the protection of significant land areas, enhance community sustainability, reduce regulatory burdens and engender citizen support for local government efforts. The Islands Trust is a federation of local governments with a provincial mandate (from the Islands Trust Act) to "preserve and protect the natural environment and unique amenities" of the Georgia Basin islands, for the benefit of both local residents and the province generally. It is focusing on tools that harness local economic development and use incentives to protect natural areas in the Islands Trust Area.

The Natural Area Protection Tax Exemption Program is a pilot program that uses tax-shifting to encourage natural area protection. Under the program, the Islands Trust Council will issue certificates that significantly reduce property taxes for those landowners willing to protect natural features on their property.

Some Official Community Plans within the Islands Trust Area have established frameworks for the large scale Transfer of Development Potential in order to protect natural areas and create more sustainable clustered settlement patterns. Over 120 ha of significant natural features on one island have now been protected. The system is being considered to partially reimburse provincial costs of parkland acquisition on Salt Spring Island.

Other island communities are expanding upon provisions for Amenity Zoning in the Local Government Act in innovative ways to exchange bonus development for large scale natural area protection.

Applications of Social Marketing in a Residential Watershed Pledge Program

Pamela M. M. Jull

Applied Research Northwest

The Whatcom Watershed Pledge program has enjoyed substantial success in three Whatcom County areas. A recent grant from the Department of Ecology is enabling the program to be adapted to marinas and small farms and expanded to new businesses and residential areas. Currently the program directors are working to integrate better evaluative components into the projects in order to move away from the question: "Does it work?" Towards

the question: "How can we make it work better?" Our primary objective is to apply more community based social marketing principals in two social experiments.

Dr. Jull will discuss the research design for two residential programs in different watersheds, including consideration of cost efficiency, program goals and priorities, timing of program elements and coordination of the program with the evaluation. Results for the Padden Creek Watershed Pledge program highlight the difference in evaluative findings between cross-sectional and longitudinal design. Upcoming projects will examine the effects of face-to-face versus mailed educational materials in producing more robust behavioral change over and above the commitment and education strategies used.

Challenges for Private Woodlot Owners in Implementing Sustainable Eco-forestry Practices in Eastern Vancouver Island

Gary Schaan

No affiliation

The area south of Campbell River on eastern Vancouver Island encompasses several of the most threatened ecosystems in the Georgia Basin. Unique in BC most of this region, extensively altered through settlements, logging, agriculture or mining, is in private hands. The level of eco-logical disturbance is high. The BC Conservation Data Centre has red or blue listed 39 plant communities within the Campbell River Forest District alone. Academia, government and the environmental community have focused on protecting the few remaining intact plant communities, (i.e. <1% of the original coastal Douglas-fir ecosystems) or on the environmental and forest practices on the large tracts owned by forest companies. Very little research or public policy effort has been directed to the importance of the large number of small scale private woodlots, typically family owned 5 to 100 hectares of second growth forest. I intend to present research (including case studies of "best practices"), first to demonstrate that these small woodlands have important, if not yet widely recognized, ecological and socio-economic values within the Georgia Basin Ecosystem; and second that there are serious institutional and economic barriers which mitigate against implementing idealized "eco-forestry" practices.

Living Green: A Watershed Pledge Program Influencing Behavioural Change to Reduce Non-Point Source Pollution

Arelia Werner

Living Green

- To raise awareness of the environmental impacts of common practices around the home and how changes in behaviour can help to improve watershed health.
- To encourage changes in behaviour of residents of BC and the Yukon.

General Methodology:

- Living Green provides individuals with concrete examples of the simple changes that they can make in an attractive calendar, which is presented to them by members of their own community. Residents are asked to commit to changing their behaviour by taking a pledge.
- The Living Green calendar is a generic product that is transferable to communities in all regions of BC and the Yukon. Stewardship groups delivering Living Green are supported by the project's Regional Co-ordinator and by a guidebook that outlines various options for program design. Outreach materials including posters, brochures, and magnets are available for adaptation. Ongoing updates are made available through the website, www.livinggreen.ca, and a quarterly newsletter.

Results:

- The communities that have adopted Living Green and how they have applied the project to their specific situation will be discussed. The types of changes individuals are willing to commit to will be presented.

Conclusions:

- The effectiveness of Living Green in changing behaviour will be discussed.

Broader Implications:

- The potential for changes in mindsets sparked by Living Green will be illustrated.

Success Through Stewardship: White Sturgeon Monitoring and Assessment in the Lower Fraser River, B.C.

Troy C. Nelson, Marvin L. Rosenau and Rick Hansen

Fraser River Sturgeon Conservation Society

An ongoing population and migration assessment of white sturgeon (*Acipenser transmontanus*) in the lower Fraser River, BC, is being conducted by the Fraser River Sturgeon Conservation Society (FRSCS), a non-profit organization dedicated to the conservation and restoration of wild Fraser River white sturgeon. The significant volunteer-driven sturgeon tagging program has coordinated activities and in-kind contributions from true stewards of the resource: sport fishing guides, recreational, commercial, and aboriginal fishermen, test fishery and enforcement personnel, and various fishery monitors. The program has gathered sponsorship and support from provincial, federal, and aboriginal governments, plus non-government institutions, associations, and foundations. Under the program, which commenced in November 1999, volunteers are trained to tag captured sturgeon with passive integrated transponder (PIT) tags, record tag numbers from any recaptured sturgeon, measure and assess the condition of captured sturgeon, and secure and transfer the data. Over 12,000 PIT tags have been applied to sturgeon during the first three years of the program within a study area that

spans over 130 linear kilometers from the Fraser Canyon (near Yale) to the Fraser estuary. The project has produced reliable population estimates, novel sturgeon life history information, and heightened awareness levels in the public regarding the state of the resource.

Session 8E: EXPOSURE AND EFFECTS OF TOXIC CHEMICALS ON WILDLIFE AND BIOTA IN GEORGIA BASIN AND PUGET SOUND

Bioaccumulation of Pollutants in Octopuses (*Enteroctopus dofleini*)

Roland C. Anderson

The Seattle Aquarium

A new octopus exhibit opening in 1999 at The Seattle Aquarium allowed the opportunity to display very large giant Pacific octopuses (*Enteroctopus dofleini*) and demonstrate their natural hunting and feeding behaviors on live crabs (*Cancer productus*) obtained from Seattle's harbor. These crabs made up 50% of the octopuses' diet. The first four male octopuses held in the tank neither grew as large nor lived as long as expected. Since water quality parameters were excellent, the diet of crabs was suspected as contributing to the early onset of the octopuses' senescence, and these crabs were eliminated from the diet. The next five octopuses grew statistically larger. Local crabs and the octopuses fed them had high accumulations of metals in the hepatopancreas of the crabs and the digestive glands of the octopuses. Octopuses from the Seattle area and from the outer coast of Washington State were examined for PCBs, which were high in both samples. Metals were likely picked up by the octopuses eating crabs living on and in historically industrial sediments of Seattle's harbor, and PCBs found in coastal octopuses likely came from the Columbia River.

Effects of Agricultural Effluent on Native Amphibians in the Lower Fraser River Valley

Christine Bishop

Canadian Wildlife Service

C. Kennedy and R. Loveridge

Simon Fraser University

John E. Elliott

Canadian Wildlife Service

Critical parameters such as hatching success, deformity rates, metamorphosis and survivorship of northern red-legged frogs (*Rana aurora*) and northwestern salamanders (*Ambystoma gracile*) were assessed at agricultural and reference study sites in the Sumas Prairie and Elk Creek watersheds of the lower Fraser Valley. Hatching and deformity rates for the two species were investigated using

Nytex mesh cages in an in situ design. Metamorphosis was studied using a mesocosm design. Hatching success was significantly lower at agricultural compared to reference sites for both species in some years. However, no differences in hatching success were observed when eggs were reared in a laboratory using transported agricultural and reference water. There were differences in water chemistry between agricultural and reference sites on the Sumas Prairie, in particular ammonia, phosphate and BOD. Further laboratory studies also examined the role of temperature on development, and the effects of agricultural runoff on thyroid hormones of red-legged frogs. Lower temperatures ($<10^{\circ}\text{C}$) had a significant negative effect on metamorphosis; the highly drained and channelized nature of the streams and ditches studied prevents the formation of wetlands and back eddies more suitable for amphibian reproduction. Analysis of non-native green frog (*Rana clamitans*) carcasses showed low levels of chlorinated hydrocarbon concentrations at all sampled sites, indicating that those particular endocrine disrupting chemicals were not a significant concern.

Altitudinal Migration Within a Watershed Influences the Contaminant Profiles of American Dippers

Christy A. Morrissey and Leah I. Bendell-Young

Simon Fraser University

John E. Elliott

Environment Canada

From 1999-2002, an intensive study of a population of American dippers was established on the Chilliwack River, a coastal watershed of southwestern British Columbia, Canada. Over 500 American dippers were individually color banded and followed to identify patterns of seasonal movement and its potential influence on contaminant burdens. The study revealed that the majority (~85%) of the dipper population seasonally migrated from the low elevation river to the higher elevation creeks while the remaining birds (~15%) remained on the river year-round. Through residue analysis of egg contents and breast feathers, we were able to detect a trend in contaminant profiles of resident and migrant American dippers. Total chlorinated hydrocarbons, polychlorinated biphenyls, and mercury were significantly higher ($p < 0.0001$, $p < 0.005$, $p < 0.001$ respectively) in eggs from river residents compared to the creek migrants. The three most prevalent organochlorine compounds in dipper eggs, DDE, hexachlorobenzene, and trans-nonachlor, were all significantly higher on the river compared to those from the creeks. Additionally, feather mercury ($p = 0.068$) and feather cadmium ($p = 0.02$), but not feather lead ($p > 0.7$), showed higher mean concentrations in the river residents. These results emphasize the importance of understanding the ecology of the species to be able to correctly assess toxicological effects at the population level.

Contaminants in Surf Scoters Wintering in the Strait of Georgia, British Columbia, Canada

Laurie K. Wilson and John E. Elliott

Canadian Wildlife Service

Populations of scoters have declined in the Pacific Northwest. These declines have gone largely unexplained and have raised concerns about contaminant exposure as large numbers of surf scoters winter in the Georgia Basin, often in polluted estuarine areas and harbours. Scoters are long-lived birds and feed principally on molluscs, a food chain known to accumulate endocrine disrupting substances. We examined temporal uptake of contaminants by surf scoters during the winter in the Georgia Basin by collecting birds during the early winter and again in the later winter at contaminated and reference sites. Carcasses underwent complete necropsy, and tissues were collected for histology, biomarkers and contaminant analysis. Hepatic EROD activity was induced in scoters collected from the harbour compared to scoters from the reference site. Over winter, the EROD activity increased significantly in scoters from the harbour whereas levels in scoters from the reference site remained constant. This response may have been induced by exposure to PAHs as a PAH-conjugated metabolite was detected in bile. Levels of chlorinated hydrocarbons and metals (Pb, Hg, Se, Cu, Zn, Cd) in scoters were minimal. Scoters wintering in the harbour had approximately 10-fold more butyltins than scoters from the reference site. Body condition of surf scoters declined significantly over the winter at both reference and contaminated sites. Further work is needed to assess if endocrine-disrupting substance exposure on the wintering grounds is contributing to population declines recorded on breeding grounds.

Assessing the Dietary Exposure of Harbour Seals (*Phoca vitulina*) to Persistent Organic Pollutants (POPs) in the Strait of Georgia, British Columbia, and Puget Sound, Washington State

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Institute of Ocean Sciences

Steve Jeffries

Washington Department of Fish and Wildlife

Michael J. Whithicar

University of Victoria

Peter S. Ross

Institute of Ocean Sciences

Elevated Persistent Organic Pollutants (POPs) concentrations have been detected in high trophic level wildlife and have been associated with endocrine disruption and other adverse health effects. Recent evidence indicates that harbour seals (*Phoca vitulina*) inhabiting Puget Sound, WA are approximately seven times more contaminated with polychlorinated biphenyls (PCBs) than those inhabiting the Strait of Georgia, BC. We are currently using an ecosystem approach to characterize the accumulation of complex mixtures of POPs in harbour seal food chains

using such tools as congener-specific contaminant analyses, stable isotope ratios, fatty acid signatures, and multivariate statistical methods. Weighted, prey-specific "food baskets," representing realistic average dietary intakes for harbour seals, were created following sampling of preferred prey species from the two basins. Total PCB concentrations in the Puget Sound seal food basket were found to be seven times higher than the Strait of Georgia seal food basket, consistent with previous observations of harbour seals in these transboundary waters. Stable carbon and nitrogen isotope ratios in seals, prey species, and food baskets suggest that Puget Sound harbour seals ($\delta^{13}\text{C} -15.8\text{‰}/\delta^{15}\text{N} 14.4\text{‰}$) feed slightly higher in the food chain than Strait of Georgia harbour seals ($\delta^{13}\text{C} -19.2\text{‰}/\delta^{15}\text{N} 12.9\text{‰}$). Based on these results, we estimate that the estimated daily dietary intake (EDI) of PCBs by a 25 kg harbour seal is 0.03mg/kg-bw/day for Strait of Georgia seals and 0.21mg/kg-bw/day for Puget Sound seals. Our research suggests that harbour seals are vulnerable to accumulating relatively high concentrations of POPs through the ingestion of contaminated prey items, and highlight the need for further research into the sources of such persistent contaminants in this transboundary region.

Chlorinated Hydrocarbons and Heavy Metals in River Otter (*Lutra canadensis*) and Mink (*Mustela vison*) samples from the Coast of British Columbia

John E. Elliott and Laurie K. Wilson

Canadian Wildlife Service

Carcasses of trapper-caught mink and river otter and faeces of otters from latrine sites were collected at sites around the Strait of Georgia and from reference sites. All samples were analyzed for PCBs and organochlorine pesticides, and selected samples were also analyzed for polychlorinated dioxins (PCDDs) and furans (PCDFs), mercury and cadmium. Results are reported on a lipid weight basis for OCs and dry weight for metals. In scats, mean mercury concentrations varied among sites, ranging from 0.083 mg/kg around Powell River to 0.55 mg/kg in Clayoquot Sound. OC pesticide concentrations in scats were low, with only DDE detected in all samples and at concentrations ranging from 0.01 to 0.15 mg/kg. Concentrations of 2,3,7,8-TCDD ranged from non-detectable ($< 1 \text{ ng/kg}$) to 111 ng/kg in a sample from near the pulp mill at Powell River. 2,3,7,8-TCDF ranged from 20 ng/kg at the reference site to 1350 ng/kg in a sample from Esquimalt Harbour. OCDD ranged from 120 ng/kg in Clayoquot Sound to 19100 ng/kg in a pooled sample from the Nanaimo area. PCBs were present in all samples; mean concentration ranged from 0.395 mg/kg near Powell River to 12.3 mg/kg in 4 samples from Victoria Harbour. The geometric mean concentration in scats from Victoria Harbour exceeded the adverse effect level for reproduction of 9 mg/kg lw suggested; scats from one Victoria Hb latrine contained 108 mg/kg total PCBs. Data on contaminant levels in livers and morphometric measurements are being analyzed and will be reported and discussed.

Session 8F: HABITAT RESTORATION AND CONSERVATION

Wildlife Habitat Conservation Strategy

Caroline Astley

Langley Environmental Partners Society

The objective of the project is to protect and restore a healthy diversity of native wildlife species and habitats throughout the Township of Langley in perpetuity. The methodology implemented to achieve this goal includes: land cover identification through ortho-photo interpretation and land cover polygon mapping, ground-truthing through visual assessments and land-owner contacts, the construction of a species/habitat database to determine critical habitat types and linked to a GIS, and working closely with municipal staff, City Council, senior agencies and the community to establish a set of achievable habitat objectives to help conserve and restore habitat throughout the township. As the project is still on-going, there are only a few results to date, but these include: the establishment of an Invasive Species Program, co-operation with the Oregon Spotted Frog Recovery Team, a successful forum on habitat issues in a local community, and the completion of the land cover mapping and database construction. Broader implications for this project include the use of the program as a pilot project for other municipal initiatives, establishing connectivity between this project and provincial and federal programs, and a way to monitor local species presence and land use on an on-going basis through community input.

The Role of Mitigation in a Restoration Strategy

Will Hall

Snohomish County Surface Water Management

Groups around Puget Sound have been formed to recover salmon, protect marine resources and address other natural resource issues. They are drafting plans to guide future restoration and protection actions by governments and non-governmental organizations. Despite concern about the potential for development to degrade ecological functions, they have done very little to guide the associated mitigation. Developers and regulators are limited in what they can do, but the large amount of money at stake makes it worthy of consideration.

Three current examples are considered. First, developing a salmon habitat conservation plan for WRIA 8 while a major regional wastewater plant is being planned. Second, developing MRC recommendations for restoration of marine resources while a major railroad improvement is planned. Third, developing a watershed plan for the Snohomish River basin while a watershed-based mitigation approach is being tested for a highway project. These examples suggest keys to success:

- Break out of the development-versus-environment paradigm.

- Engage the development community from the beginning.
- Explicitly include mitigation in the strategy.
- Recognize that criteria are different.
- Include potential mitigation projects.
- Get the strategy in place ahead of specific applications.
- Make it well known.

Modeling Ecosystem Integrity: Decision Tools for Prioritizing Stream Restoration

William Kleindl, Lucinda Tear, Chip Maney, Pete Lawson and Bill Lavoie

Parametrix, Inc.

Stream enhancement projects are increasing at unprecedented rates in the Puget Sound region. To allocate limited resources effectively, projects must be prioritized using best available science. To assist in prioritization of enhancement projects in multiple drainages, an aquatic habitat assessment model was developed for Snohomish County, WA. We developed an ecologically based decision tool that was (1) appropriate in scale, cost-effective, and management focused, and (2) used regionally appropriate reference conditions to compare sites and detect degraded conditions. The result was a multimetric habitat model—the “Index of Habitat Integrity” (IHI). The development of the IHI included an assessment of over 60 different physical habitat attributes (e.g. woody debris, unstable banks) sampled in drainages that varied in degrees of human disturbance as measured by different land cover attributes (e.g. impervious area, forest cover). Physical attributes that changed in predictable ways with increased human influence provided meaningful indicators of habitat response to perturbation. Six habitat metrics, which met this qualification, were combined into the model. The IHI model is used in conjunction with the benthic index of biotic integrity (B-IBI) as restoration prioritization decision tools.

Monitoring Restoration of Off-channel Habitats for Pacific Salmon

Sarah Morley, Patricia Garcia, Todd Bennett and Phil Roni

Northwest Fisheries Science Center

Off-channel habitats (such as sloughs, beaver ponds, wetlands and other permanently or seasonally flooded lands) are important rearing areas for juvenile salmonids. As floodplains have been routinely isolated or impacted by adjacent land use practices, off-channel habitats have been lost. The objectives of this project are to determine the effectiveness of various off-channel habitat restoration techniques by (1) gathering and summarizing known information on off-channel salmonid production, and (2) determining what physical, biological, and hydrological features characterize the most successful projects. Based on analysis of smolt-trapping data from over 30 off-channel

sites in Washington State, we found that constructed groundwater channels were particularly productive for juvenile coho salmon (*Oncorhynchus kisutch*). We evaluated fish use at a set of constructed and reference groundwater channels in two geographic provinces: the North Sound and Olympic Peninsula of Washington State. Although we observed five salmonids species using these off-channel habitats, coho overwhelmingly comprised the dominant species, particularly at constructed channels. We also collected temperature, nutrient, and invertebrate data so as to evaluate the specific relationships between these site characteristics and fish use parameters. Knowledge of these relationships will help to establish future guidelines for the design and construction of off-channel habitats.

Water Quality as a Contemporary Limiting Factor to Olympia Oyster Restoration in Washington State

J. Anne Shaffer

Washington Department of Fish and Wildlife

The purpose of this study was to define the response of Olympia oyster to the contemporary water quality environment of Puget Sound. Through a one year field experiment, Olympia oyster growth, mortality, and tissue loading of metal and organic pollutants was assessed to define the role water quality may play in restoration of Olympia oyster to Washington waters. Results indicate that nonpoint source pollution of non-metropolitan areas, a significant contemporary water quality feature for inland marine waters of Washington, does not appear prohibitive to Olympia oyster restoration. While keen assessment of potential sites is a critical component to oyster restoration, water quality may be less of a factor than other limiting factors, such as predators, for initial site selection. Within the range of this study, high levels of fecal coliform levels, turbidity, or organic pollutants do not appear to be indicators of poor Olympia oyster habitat. High zinc levels may impact Olympia oyster growth and mortality and so may be a concern for restoration success. Sites with elevated zinc should therefore be given extra consideration and possibly lower priority. The Olympia oyster's tolerance for contemporary water quality is an encouraging factor when considering Olympia oyster restoration options.

Session 9A: DESIGNING MARINE RESERVES

National Marine Conservation Areas: Proposals for a Federal Government Program Structure on the Pacific Coast of Canada

Wayne L. Bourque

Parks Canada, Western Canada Service Centre

The government of Canada enacted legislation in 2002 to establish a system of National Marine Conservation Areas in Canada (NMCA). Based on a review of the program information and a literature review of the management

concept prescribed for the program, criteria are identified for a federal program structure that could administer the management and use of NMCA. A subsequent review of existing federal programs and services against the identified criteria is used to formulate proposals for a federal government NMCA program structure on Canada's Pacific coast.

The review identifies ecosystem-based management, sustainable use, and the precautionary principle as the essential elements of the management concept prescribed for NMCA program. Highlighted are some of the challenges in designing and implementing a program structure for the NMCA program. Through the information reviews and concurrent interviews with department and agency representatives, federal programs and services that could support the NMCA program on the Pacific coast are identified. Considering this information and the implications of the literature review, proposals are presented for an NMCA program structure. An ethical approach is used to present the proposals in this paper as a means to initiate an informed dialogue between the respective federal agencies for the NMCA program on the Pacific coast.

Site Conservation Planning for Marine Biodiversity Richness Zones within the Orca Pass International Stewardship Area

Mike Sato and Philip Bloch

People For Puget Sound

Peter Ronald

Jeff Ardron

Jacques White

People For Puget Sound

Regional conservation planning efforts require both science to identify sites to be conserved and policy to identify conservation and management options. Within the Orca Pass International Stewardship area we have used regional species and habitat information to identify distinct richness zones. We used is a representation-based conservation strategy to identify these sites, enabling us to overcome some of the limitations of species-by-species approaches by expanding the focus of conservation to include overall biodiversity and by association, ecosystem process.

While the overall goal for the Orca Pass International Stewardship Area is to steward, conserve and restore local marine associated living resources, there is a gap between identifying the distribution and abundance of resources and appropriate management of those resources. Therefore, identifying priority sites for conservation completes one phase, and leads directly into another—site conservation planning. Site conservation planning in Orca Pass involves combining a suite of resources known or believed to occur at a given site with a prospective list of regulations and best management practices. This approach provides a transparent, repeatable process for identifying locations for enhanced conservation and stewardship actions and for partnering with local and regional interests to establish

tailored management plans for specific zones within a larger stewardship area.

Could the San Juan Island National Wildlife Refuge Serve to Protect Marine Areas? An Evaluation of Refuge Nearshore Buffer Zones Relative to Their Function as Marine Protected Areas

Cristen Don

University of Washington

The San Juan Islands National Wildlife Refuge comprises 83 small islands and rocks scattered throughout the San Juan Archipelago in Washington State. Current guidelines set by USFWS advise vessels to stay 200 yards offshore from refuge sites to provide a marine buffer for birds and marine mammals who utilize the refuge. Compliance with the existing guidelines provides inherent protection to the intertidal and subtidal resources within these marine buffer zones and could arguably constitute a de facto network of (Marine Protected Areas (MPA) in the region. A two-part study was undertaken to evaluate nearshore buffer zones in the NWR relative to their function as MPAs. The first part examined biological and physical attributes of buffer zones to quantify potential contribution to marine protection in the region, using existing data to classify marine habitats within buffer zones. The second part reviewed institutions and legal authorities that could potentially bolster protection and management to marine areas of the NWR. Two major conclusions were derived from the study. One, the NWR is capable of serving as a viable network of MPAs contributing to regional resource protection. Two, success of the MPA will likely depend on the formation of partnerships between a variety of agencies and institutions.

Acoustic Telemetry of Copper Rockfish (*Sebastes caurinus*) Home Range to Determine Minimum Marine Protected Area Size

Eric Eisenhardt

San Juan County Marine Resource Committee

The goal of the study was to describe the area of habitat used, or home range, by adult copper rockfish inside two San Juan County voluntary “no-take” zones. The methodology involved tagging sixteen copper rockfish with acoustic transmitter tags, and tracking them daily for two months. Tracking was accomplished using a boat with a hydrophone receiver and GPS unit or by passive hydrophone arrays linked to a land-based station. Results showed that most copper rockfish stayed inside the MPA, however fish did move outside—indicating potential for adult spillover and thus properly sized MPAs for copper rockfish. These results generally support previous findings by Matthews (1990) of home range size on the order of 30m² in Puget Sound on patch reefs with high substrate complexity, however, extension to the San Juans shows that these fish can inhabit larger home ranges when continuous, high substrate complexity, rocky reef habitat is available.

Session 9B: PEOPLE AND PROCESSES— COLLABORATIVE MANAGEMENT (II)

The Tulalip Tribes Cultural Stories Project: Recording and Using Traditional Knowledge for Cultural Landscape Recovery, Watershed Management and Salmon Protection

Julia Gold, Preston Hardison and Terry Williams

Tulalip Natural Resources

Over the past two decades, the Tulalip Tribes have embarked on a program to manage and restore their watersheds and protect and recover habitat for salmon. For indigenous peoples, any environmental restoration involves biocultural restoration, since the culture cannot be separated from the land. The Cultural Stories Project has been developed to complement the biophysical models the Tulalip developed for watershed management. The project uses interviews with elders to document the cultural and traditional uses of resources and their importance to Tulalip Tribal members. These are used to characterize historical cultural landscapes and resources, their perceived current state, and the future desired states. This information is correlated against historical accounts from the literature and scientific documentation, and these are integrated with the biophysical watershed models to establish goals for restoration efforts. We describe the methodology for this process, some of the software tools developed for managing traditional knowledge, and issues concerning privacy, knowledge protection, and the use of indigenous knowledge in interaction with external federal, state and municipal agencies involved in watershed management and Pacific salmon endangered species protection. Finally, we explore the importance of this process for the cultural health and well-being of the Tulalip Tribes and their homeland.

Ecosystem Planning in the Georgia Basin, Puget Trough and Willamette Valley Ecoregion: A Transboundary Approach

Pierre Iachetti and Chuck Rumsey

The Nature Conservancy of Canada

Marcy Summers

The Nature Conservancy, Washington Field Office

The Nature Conservancy of Canada, The Nature Conservancy (US), and their provincial, state and federal partners, have completed a transboundary conservation planning strategy for the Georgia Basin, Puget Trough and Willamette Valley ecoregion which identifies areas of biodiversity significance containing multiple, viable (or feasibly restorable) examples of all native plants, animals, and ecological communities across important environmental gradients.

To achieve this goal, we used the “coarse-fine filter strategy,” a working hypothesis that assumes conservation

of multiple, viable examples of all coarse-filter targets (communities and/or habitat types) will also conserve the majority of species. Those species that the coarse filter cannot reliably conserve require individual attention through the fine filter approach (e.g., wide-ranging, rare, narrowly endemic, or keystone species).

The results of this planning project yielded a portfolio or network of lands and waters for conserving the elements of biodiversity within the ecoregion that best represents the native species and ecosystems of the region and the underlying ecological processes that sustain them (Groves et al., 2002).

Ecoregions, not political boundaries, provide a framework for capturing ecological and genetic variations in biodiversity across a range of environmental gradients. This strategy provides a more practical alternative to surveying every species, and provides a cost-effective means for simultaneous conservation and recovery of groups of species (Simberloff 1997). Protecting and restoring ecosystems also serves to protect species about which little is known and provides the opportunity to protect species while they are still common (Noss 1990).

Water Resource Management Practices in Northwest Russia and Their Impact on the Baltic and Barents Seas

Nathaniel Trumbull

University of Washington

Northwest Russia faces a number of environmental problems on the local, regional and global scale. Water resources are particularly critical to the Northwest region of Russia in terms of population health, economic development, and the management of other natural resources in the region. Lake Ladoga, the largest lake in Europe, serves a variety of functions: the main drinking water supply for St. Petersburg's 4.6 million population; a source of water for industry and agriculture; and an important waterway for navigation. The water quality of Lake Ladoga had deteriorated significantly by the last decades of the Soviet period. My research question is the following: how and to what extent have the economic, social, and institutional developments of the transition period impacted the quality of the water resources of the Russian Northwest? My hypothesis is that despite lower industrial production in the early 1990s, which reduced negative impacts on water resources in the region, Russia's water resources and those of neighboring nations have increasingly been placed at security risk from rising consumer activity, renewed industrial production at the end of the 1990s, and unresolved radioactive dangers. An evaluation of the effect of those water management practices on the Baltic and Barents Seas is an integral part of my research.

Western Washington Inter-Agency Dredging Coordination Workgroup—An Interagency, Cross-jurisdictional Success Story

Philip L. Hoffman and George Hart

U.S. Army Corps of Engineers

Management of dredging operations in western Washington requires the Army Corps of Engineers (USACE) to interact with agencies at the federal, state, and local levels. Dredging projects are often opposed at various levels due to poor communication, bureaucratic unresponsiveness to legitimate concerns and issues, and misunderstanding of methods and project necessity. Recognizing these constraints, the Seattle District, USACE, created an interagency work group in 1998 to facilitate collaboration among various agencies. A formal agreement between agencies allows staff to coordinate through the work group without seeking higher approval. Semi-annual meetings allow staff to exchange information, update activities, and direct work to the appropriate agency. The work group has been successful in removing barriers to timely concurrence on Endangered Species Act issues (6 months down to 2-4 weeks), eased tensions between agencies, and created a better understanding and acceptance of the need for and benefits of dredging in the maintenance of navigable waterways in western Washington. A beneficial use work group has also grown from this effort.

Session 9C—Panel : FISH HABITAT AND STEWARDSHIP IN BRITISH COLUMBIA

Discussion of Canada's Stewardship Agenda, the end of the Habitat Conservation and Stewardship Program (HCSP) and challenges facing stewardship in British Columbia

- **Ted Cooke**, Fisheries and Oceans Canada, Ottawa
- **Lisa DeGoes** Fisheries and Oceans Canada, Pacific, Habitat Enhancement Branch
- **Carl Sam**, Squamish River Watershed Society
- **Andrew Appleton**, HCSP Stewards-Lower Fraser
- **Mark Pakenham**, Veins of Life

Session 9D—Panel : ASSISTED BY SCIENCE, EMPOWERED BY PUBLIC PROCESS: HOW CITIZEN LEADERSHIP CAN PROTECT AND RESTORE THE MARINE ENVIRONMENT

Discussion by panel of Marine Resource Committee members and scientists working with the Northwest Straits Marine Conservation Initiative that will focus on findings and ongoing projects, as well as discuss the public process that is driving this place-based experiment in marine conservation.

- **Andrea Copping**, University of Washington, *“Northwest Straits Marine Conservation Initiative”*
- **Gary Wood**, Executive Director of Island County Marine Resources Committee, *“Forage Fish Spawning in Island County”*
- **Kirby Johnson**, Snohomish County Marine Resources Advisory Committee (MRC), *“Snohomish County MRC Dungeness crab stewardship plan”*
- **Tom Cowan**, Northwest Straits Executive Director, *“Hazards and Removal of Derelict Fishing Gear”*
- **Rhea Miller**, San Juan County Commissioner, *“Citizen Involvement in the Protection of the Marine Environment”*

Session 9E: ECOSYSTEM ASSESSMENT AND MANAGEMENT

Ecosystem-based Management Should Include an Assessment of the Impacts of Pacific Salmon Enhancement and Escapements on Associated Salmon Species in the Strait of Georgia

R.J. Beamish, C. M. Neville and R. Sweeting
Fisheries and Oceans Canada

Decisions relating to escapement or enhancement of Pacific salmon implicitly consider that the ecosystem within the Strait of Georgia is able to accommodate the changes in juvenile abundance of one species without important impacts on associated species of salmon. We show that there is diet overlap among pink, chum, sockeye, coho and chinook in the first few months of ocean residence. Thus, decisions to produce large numbers of chum salmon or to escape large numbers of pink salmon to the Fraser River may affect the growth of associated species. Because smaller fish are less able to survive periods of energy deficits in the first marine winter, factors that

reduce growth could directly reduce total marine survival. Ecosystem-based management, therefore, should include the management of what is added to the Strait of Georgia as well as to what is naturally produced in the Strait.

Back to the Future in the Strait of Georgia/ Puget Sound

Nigel Haggan
UBC Fisheries Centre

Modern industrial fishing has changed the trophic structure of marine ecosystems. The phenomenon of fishing down the food web—catching all the high-trophic level table fish then gearing up to go after their prey—has been well documented at global and national level. The South China Sea is a particularly advanced example where large fish are gone, but fishers still make a living catching small fish as feed for the agriculture and aquaculture industries. Back to the Future (BTF) project combines different types and systems of knowledge, to make computer models of ecosystems at different times in the past. This baseline resetting facilitates the setting of restoration goals that relate to productive potential rather than present scarcity.

The first BTF project was in the Strait of Georgia in 1996-98. Researchers combined scientific, historical, archival, traditional and local ecological knowledge and other sources to create models of the system as it might have been 100 years ago, and a preliminary 500 year ago model, when Stellar’s sea cows were still present.

Conceptual Models as a Tool for Assessing, Restoring, and Managing Puget Sound Habitats and Resources

**Ronald M. Thom, Gregory D. Williams
and Amy B. Borde**
Pacific Northwest National Laboratory

Factors that control the abundance and dynamics of habitats and resources are often not quantitatively understood. Conceptual models (e.g., box and line diagrams) are one useful method of organizing information on those factors that control habitat and resource dynamics. These models can be used to facilitate habitat monitoring, restoration, and ecosystem management. Two decades ago, the Chesapeake Bay National Estuary Program developed a simple model that has guided the monitoring program and driven restoration actions valued at millions of dollars. More recently, large ecosystem restoration programs in the Mississippi River delta and Florida Everglades have also incorporated conceptual models. In 2001, we developed a conceptual model for the Columbia River estuary to help trace the impacts of the proposed navigation channel deepening on juvenile salmon and other resources. In Puget Sound, we are currently employing a conceptual model to help improve eelgrass restoration and to understand the effects of shoreline development on nearshore marine habitats. The models present a logical, science-based method for evaluating potential multiple stressors on coastal ecosystems, planning restoration projects and refining

a practical monitoring program, incorporating lessons learned, and communicating information on the programs to the public.

Defining Coastal Processes for Nearshore Habitat Protection in Puget Sound

Jim Johannessen

Coastal Geologic Services, Inc.

Several recent Coastal Geologic Services studies that defined coastal processes in discrete areas with important nearshore habitat resources will be discussed. Nearshore habitats have formed because of the dynamic equilibrium between natural bluff sediment input to the net shore-drift system and the existing wave climate. The presence and maintenance of these habitats is completely dependent on continued bluff sediment input and the lack of disturbance to the net shore-drift (littoral) system, and therefore science-based management plans are essential. A report on Port Townsend Bay and northern Hood Canal was prepared for Jefferson County, in conjunction with a nearshore habitat characterization. Three types of critical shoreline areas for maintaining the critical nearshore habitats were mapped: feeder bluff, contributing bluff, and accretion shoreform. A second CGS study on the eastern Clallam County was completed in 2001. This study provided a long-term shoreline change and coastal processes context in which to consider applications for shoreline modifications. The report included recommendations for shoreline management regarding shore defense proposals. A third study in south Birch Bay was prepared for Whatcom County in 2002. This study included geologic and coastal processes, historic shoreline change, inventory work, and recommendations for non-structural coastal erosion control options.

Monitoring of the Lower Fraser River Using Fish Assemblages: Can it be Done Without Reference Conditions?

John S. Richardson and Scott G. Hinch

University of British Columbia

Biomonitoring uses the responses of whole communities to environmental changes as an assay of undesirable alterations, relative to some reference condition. Often there are no true references because ecosystems are unique, or comparable reference conditions have been lost, such as for the lower parts of the Fraser River including the estuary. We have sampled the fish assemblages in the lower Fraser River 6 times over 28 years to detect changes in community structure and to assess if any patterns can be interpreted in terms of foodweb interactions, or direct effects of the physical and chemical environment. Fish assemblages have shown large differences from year-to-year (up to 3-fold differences in biomass and numbers between years). Large variation in annual reproductive success of species may contribute to shifts in abundance and structure. Several of the 36 species are long-lived (e.g. largescale sucker) and may archive details on year class strength, which we will need in order to test this source of variation. The absence of continuous, long-term time series of data,

lack of reference sites, non-stationarity of the system, and little detailed understanding of the lower Fraser River's ecosystem challenges our methods available for assessment of ecosystem condition or trend.

Stream Assessments in the Georgia Basin Using the Reference Condition Approach for Benthic Invertebrate Monitoring

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Acadia Centre for Estuarine Research

In 1998-2002, more than 50 reference sites from the lower Fraser Valley and eastern Vancouver Island were sampled and added to the existing Fraser River Basin benthic invertebrate database for reference condition. The Fraser River Basin predictive model was re-developed specifically to include these and other sites in the Georgia Basin. More than 40 sites were sampled from streams exposed to agricultural and urban activities in the Georgia Basin and assessed using the reference condition approach based on abundance predictions as well as a RIVPACS-type approach based on taxonomic predictions. Eight sites were also re-sampled in subsequent years to assess repeatability of the assessment. Most assessments were similar in multiple years. The streams indicating the most stress on the invertebrate community were those exposed to urban activities; this stress may be a consequence of dramatic hydrological changes during rain events.

Session 9F: NEARSHORE AND SUBTIDAL BIOTA

Coastal Biota Survey of the Tidelands of the Swinomish Tribal Community

Todd Mitchell and Rachel LovellFord

Swinomish Indian Tribal Community-Water Resources Program

The Coastal Biota Survey Project (CBS) consisted of a four-part project implemented in 1999 by the Swinomish Indian Tribal Community (SITC) and the United States Environmental Protection Agency through the Tribal Environmental Assistance pilot project. CBS is an example of extensive and achievable research on a tribal reservation. Main objectives of the project were to map eelgrass beds, survey the intertidal biota, and establish tools for accurate tide level readings. The tidelands are a culturally important resource for the Swinomish people and require environmental management. The four components of CBS were: the eelgrass survey, the shellfish population survey, NASA over flight, and the tidal standards survey.

The eelgrass survey involved a reconnaissance-mapping project, a dive team survey of the mapped areas, and a

density survey of eelgrass beds. The shellfish population survey consisted of sampling randomly selected species on commonly harvested Swinomish Indian Reservation (SIR) tidelands. The NASA over flight mapped vegetation using remote sensing and color infrared photos. Through the tidal standards survey permanent benchmarks were established on the Reservation tidelands.

The eelgrass survey mapping was successful and provided baseline population/density amounts used for processing the remote sensing maps. The shellfish survey provided valuable population parameters. The NASA over flight has produced infrared photos, but remote sensing results remain unprocessed. Tidal elevation standards have been established as a result of successful permanent benchmark placing.

Fish Species Composition, Timing and Distribution in Nearshore Marine Waters: A Synopsis of 2001-2002 Beach Seining Surveys in King County, WA

Jim Brennan and Kollin Higgins

King County Department of Natural Resources and Parks

Although historic fish surveys have been conducted in Central Puget Sound, there has never been a systematic collection of data to determine baseline composition, timing and distribution of nearshore marine fishes in King County. Furthermore, little is known about juvenile salmon timing, distribution and other life history characteristics in Puget Sound nearshore marine waters. Therefore, the purpose of this study was to establish a baseline and begin to fill critical data gaps on fish species composition, timing and distribution in nearshore waters throughout King County, Washington. Beach seining surveys were conducted from May through October in 2001 and 2002. Twelve sites were sampled consistently during 2001, with seven of the 12 sites sampled consistently during 2002. An additional six sites were sampled periodically during the 2002 sampling period. All fish captured were identified and enumerated. All salmonids and at least a subsample of all other species were measured in length to the nearest millimeter. Salmonids were also weighed in 2002 and a subsample of salmonids (primarily juvenile chinook) were lavaged and stomach contents preserved for dietary analysis. Salmonids were checked for coded wire tags and pit tags. Quantitative and qualitative habitat data were also collected from each of the sampling sites. Results on species composition, timing, distribution, growth, diet and relationships to habitat variables will be presented.

A Geoduck Distribution and Abundance Survey in the Central Basin of Puget Sound

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King County is planning a new regional wastewater treatment facility that will require construction of a marine outfall located in the Central Basin of Puget Sound. Extensive oceanography, geophysics, water quality, habitat,

and biological resource studies have been conducted in the candidate marine outfall zones. Due to the regional importance of geoducks as a commercial resource, a geoduck density, distribution, and biomass survey was performed. The geoduck survey was conducted in April and May 2002. The survey area included approximately 11.3 kilometers of shoreline, at depths between approximately -1.2 to -21.3 meters referenced to Mean Lower Low Water. Almost 6,000 meters of transect lines, placed perpendicular to the shoreline, were surveyed by SCUBA divers. Along with the measurement of density, distribution, and biomass, samples were collected for tissue chemistry and age analysis, as well as for commercial grading. The survey indicated that geoduck population density increased with depth and was highest at the deepest depths sampled. In contrast, individual geoduck biomasses were higher in the shallower depths and decreased significantly with depth. Survey data indicated that geoducks were ubiquitous throughout the study area, between the lower edge of eelgrass habitat and the deepest sampling depth.

Managing Washington State Seagrass Resources –New Directions for a New Millennium

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University of Washington

Seagrass is an essential component of coastal marine ecosystems in the northeastern Pacific, where it has substantial ecological, economic and cultural value, and where it is a focal species for scientific study and natural resource management. Seagrass is threatened by both natural and anthropogenic disturbances, and recent reports have shown a decrease in seagrass abundance globally.

Two genera and five species of seagrass grow in the waters of Washington State. In the Puget Sound, threats to seagrass include but are not limited to dock construction, dredging and filling, and loss of water quality due to sediments and contaminants. Despite the need for management, Washington State presently lacks a formal seagrass management policy. In this paper we review existing seagrass management programs and suggest strategies for management program development in Washington state.

Physiographic Controls on the Distribution of Eelgrass (*Zostera marina*) in Hood Canal

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U.S. Geological Survey

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Ralph Garono

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What controls the distribution of intertidal eelgrass? The native species of eelgrass (*Zostera marina*) provides habitat that both promotes biodiversity in Puget Sound and serves

juvenile salmon. We are using four data sets to investigate physiographic controls on eelgrass distribution:

1. An integrated topographic-bathymetric digital elevation model with 10 m X-Y resolution (and somewhat less accuracy).
2. Synthesized tide-gauge data, required to produce the integrated elevation model, that describes tidal planes (MLLW, MLW, MSL, MHW, MHHW).
3. Predictions of shoreline wave energy from a wind model and fetch using the Sverdrup-Munk-Bretschneider method.
4. Classified, georegistered, 1.5-m resolution CASI aerial hyperspectral imagery of intertidal areas along Hood Canal.

We are interested in possible correlations of eelgrass distribution with daily and monthly maximum drying time, daily and monthly maximum and minimum water depths, and predicted average and annual maximum wave energy. We will examine our analyses' sensitivity to analytical cell size, to probable error in DEM elevation, and to error in georegistration of CASI images.

Soundwide Eelgrass Monitoring in Puget Sound: 2000-2001 Results

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As part of the Nearshore Habitat Program, Washington State Department of Natural Resources implemented the Submerged Vegetation Monitoring Program in 2000. Primary objectives of the program is to track changes in abundance and maximum subtidal growth of *Zostera marina* (eelgrass) of Puget Sound and the Straits of Juan de Fuca because these plants are indicators of water quality conditions and a vital nearshore habitat. Study area boundaries were based on historical presence of eelgrass. To balance our desire to detect trends over time and characterize the status throughout the entire study area, we chose a rotational random design to sample 75 sites. This approach provides an estimate of change over a 10-year period and allows us to attach confidence limits to our estimates. At each site, using a transect-based sampling method, we obtained data to delineate minimum and maximum depth and create polygons that designate basal area coverage. Based on data collected in 2000-01, we estimate that there has been a 5 percent increase in eelgrass in the study area and the distribution of plants is primarily subtidal. These data provide the first comprehensive baseline for Puget Sound and help direct resource management programs designed to monitor water quality and protect nearshore habitat.

Session 10A: EVALUATION AND ASSESSMENT OF MARINE RESERVES

Time Will Tell: Long-term Observations of the Response of Rocky-Habitat Fishes to Marine Reserves in Puget Sound

**Wayne A. Palsson, Robert E. Pacunski
and Tony R. Parra**

Washington Department of Fish and Wildlife

The Washington Department of Fish and Wildlife has established a series of marine reserves in Puget Sound and the San Juan Archipelago that have prohibitions on the harvesting of bottomfishes. Most of these reserves are located where rocky habitats predominate, and now account for 15% of the available nearshore rocky habitat in some sub-basins. The rockfishes (genus *Sebastes*), lingcod (*Ophiodon elongatus*), and other species attracted to rocky habitats have been monitored at a number of these sites with a variety of visual census techniques. Some reserves sites and comparable fished areas have been monitored since 1992.

At Brackett's Landing (formerly Edmonds Underwater Park), a reserve established in 1970, large copper and quillback rockfish were in far greater abundance between 1993 and 1997 than at nearby fished sites. However, after a hiatus in monitoring, rockfish densities were found to have declined dramatically at the long-term marine reserve. The densities of large lingcod, however, appeared to have not changed substantially at Brackett's Landing during the same period. At reserve sites in the San Juan Archipelago, rockfish densities have not changed dramatically from the densities observed during the mid-1990s. In contrast, lingcod densities at reserve sites in the San Juans have substantially increased since 1990s and large lingcod have become more abundant during the winter spawning period. While lingcod densities have also increased in comparable fished areas in the San Juans, large lingcod and nesting activity is relatively low and unchanged. In Hood Canal, where a series of reserves was created beginning in 1994, rockfishes have become relatively more abundant and larger since monitoring began in 1996. The differing patterns in fish abundance observed at long-term and newly-created reserves may be due to the age of reserve, size, natural substrate, and degree of fishing and disturbance.

A Marine Protected Area Monitoring Technique for Nearshore Rocky Reef Fish: An Example From San Juan County's Bottomfish Recovery Program

Eric Eisenhardt

San Juan County Marine Resource Committee

Empirical monitoring data is needed to inform policy makers of Marine Protected Area effectiveness. In particular, trends over time in population density, length-

frequency distribution and species richness are needed from both reserve and non-reserve reference sites. Examining shifts in temporal trends can control for environmental variation when analyzing these variables for reserve effects. Habitat data need to be collected as well, to control for differences in microhabitats among sites. A monitoring technique has been developed with these applications in mind. The technique uses a team of four divers to quantify the above variables at each reserve site and associated reference site on the same day within an hour apart between surveys. To date, seven pairs of reserve sites and non-reserve reference sites have been surveyed to provide a baseline. The resultant data will be presented. In the near future, these sites need to be resurveyed to begin the time series. In addition, use of the methodology should be expanded to other sites in the Georgia Basin / Puget Sound region.

Using Multibeam Bathymetry to Characterize Rockfish Habitat in San Juan County, Washington Marine Reserves

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Moss Landing Marine Laboratories

W. A. Palsson

Washington Department of Fish and Wildlife

The establishment of marine protected areas (MPAs) has recently become an important part of marine resource management efforts around the world and in San Juan County. Rockfish are economically important bottomfish whose populations have declined since the 1970's to such an extent that they are being considered threatened or endangered under the Endangered Species Act. During October of 2000, Moss Landing Marine Laboratories, Center for Habitat Studies surveyed five sites within the San Juan Archipelago (SJA) using a RESON 8101 multibeam bathymetric system. Both bathymetry and backscatter data were collected, although the system was maximized for the collection of accurate bathymetry. The main objective of this survey was to gather high-resolution bathymetric data to be used in mapping adult and juvenile rockfish habitat as part of an effort to identify potential marine reserves within the SJA. Sites were chosen based upon previous knowledge of the area's physical, oceanographic, and biological conditions. Surveys were undertaken within San Juan Channel, southern Haro Strait, and southern Rosario Strait. Areas of rugged rocky seafloor were identified using both qualitative and quantitative methods, and were interpreted to be potential adult and juvenile rockfish habitat. Potential habitat bridges radiating outward from protected areas were outlined based upon visual interpretation of multibeam imagery. Three voluntary no-take reserves (VNTZs), Pile Point, Charles Island, and Bell Island established by the San Juan County Marine Resource Committee in 1997, were evaluated based upon the presence of potential adult and juvenile rockfish habitat and the existence of possible habitat bridges that radiate outward from the protected areas. Results show that Pile Point, Charles Island, and Bell Island VNTZs appear to contain viable refugia for adult and

juvenile rockfish and prospective habitat bridges that radiate outward from the VNTZs. Alternative reserve locations were also identified that may provide protection for species other than bottomfish.

Using Surface Current Models to Predict Particle Movement in the Eastern Basin of Puget Sound: Implications for Marine Protected Area Design

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The eastern basin of the San Juan Archipelago (SJA) has been hypothesized to serve as an essential collection and dispersal zone for larval transport throughout the area. We used a tidal circulation model of surface heights and currents for the entire region to simulate the paths and endpoints of passive drifters over a period of 1-4 weeks, originating from four locations in the eastern basin. Results show that drifters are strongly influenced by tidal cycles with a high retention at specific locations within the eastern basin, both on and offshore. Onshore landings correspond with results from previous drifter studies in the region. Offshore points of concentration included the southern opening of Rosario Strait at the southern end of Lopez and Whidbey Islands, the leeward side of Dungeness Spit, the western edge of Juan de Fuca Strait, and the western shore of San Juan Island. Larval collection zones feed higher trophic levels and associated food webs; correspondence with seabird distributions was also observed. Given the high potential for successful larval linkages and areas of both import and export within the basin, these results imply that a functional network of marine protected areas could be developed in the Georgia basin region.

Designing, Implementing, and Monitoring Marine Reserves: An Example from the Florida Keys National Marine Sanctuary

Brian D. Keller

Florida Keys National Marine Sanctuary

The Florida Keys National Marine Sanctuary is a 9,850-km² marine protected area that was designated by Congress in 1990. A comprehensive management plan was implemented in 1997 to protect and conserve marine resources. A key aspect of the management plan is the creation of a network of 23 fully protected zones (marine reserves); the Tortugas Ecological Reserve was implemented in 2001 as the 24th fully protected zone and is the largest marine reserve in U.S. waters (518 km²). An ongoing monitoring program is designed to determine effects of "no-take" protection on heavily exploited fishes and invertebrates, benthic communities, and human activities. Data on the abundance of reef fishes and spiny lobster; lobster size; benthic cover; and ecological processes are collected from fully protected zones and adjacent reference sites. Socioeconomic analyses are also being conducted. Preliminary reports indicate increases within fully protected zones in the number and size of heavily

exploited species such as spiny lobster and certain reef fishes. Slower-growing benthic species such as corals and sponges have not shown significant changes within fully protected zones, possibly because the zoning plan was implemented only five years ago. No strong, negative socioeconomic impacts of marine zoning have been determined.

Session 10B: PEOPLE AND PROCESSES— COLLABORATIVE MANAGEMENT (III)

The Legal and Institutional Context of Incorporating Indigenous Knowledge into Fisheries Management

Preston Hardison and Terry Williams

Tulalip Natural Resources

In the last two decades, indigenous knowledge has increasingly become an object of national and international law and policy. An increasing number of international processes are beginning to address legal and ethical issues surrounding the use of traditional knowledge, such as formal United Nations conventions, intergovernmental agreements and standards of practice, non-governmental organization policies, and academic society ethical guidelines. Indigenous peoples themselves are increasing their involvement in these processes, but their involvement at the international level is problematic and uneven. Here we review the evolving context of indigenous standing in international conventions such as the Convention on Biological Diversity (CBD), the United Nations Human Rights forums, and the conventions administered by the World Intellectual Property Organization (WIPO). We then review some of the major policy and guideline documents, focusing on those related to fisheries management. We then review the significant barriers to the development and implementation of these laws and guidelines into national law and standards of practice. We then review how these issues are being addressed in national legislation in Canada and the United States, and suggest policies to surmount some of these barriers.

The Role of the Snohomish County Marine Resources Advisory Committee (MRC) in the Northwest Straits Initiative

Kirby W. Johnson

*Snohomish County Marine Resource Advisory
Commission*

The marine ecosystem and resources in the Northwest Straits (northern Puget Sound and the Straits of Juan de Fuca) are in decline. Depleted resources have hurt economies and communities in the area. Seven counties guided by the Northwest Straits Initiative, have formed Marine Resource Committees (MRCs) to address the issues. The MRCs are over half way through a five year period mandated to produce measurable progress in meeting specific benchmarks.

The Snohomish County Marine Resource Advisory Committee (MRC) is an 11 member group of citizen volunteers representing economic, recreational, conservation, and environmental interests along with local and tribal governments. The role of the MRC is to address local issues and guided by science and the needs of the marine ecosystem, to advise county officials of remedial action.

Snohomish County is the most populous of the 7 counties and has heavily impacted it's shoreline and marine resources. The MRC has conducted public outreach and education programs and used feedback to identify water quality, nearshore habitat, forage fish and Dungeness crab as areas of focus. Plans are being formulated to initiate local action to protect and restore marine habitat and resources.

Public Process and the Creation of the Race Rocks Marine Protected Area

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Rod Dobell

University of Victoria

This research project evaluates the successes and shortcomings of the consensus process associated with the proposed XwaYeN (Race Rocks) Marine Protected Area, near Victoria, BC. Known as the Race Rocks Advisory Board, this process included government, aboriginal and stakeholder representatives, and was successful at negotiating consensus recommendations in support of designation. Among the recommendations were provisions for the creation of a no-take zone, and for the co-management of Race Rocks by First Nations, BC and Canada. The boundary of the no-take zone was a political compromise that gave only cursory consideration to scientific studies. The provision for co-management was a bold attempt to create a highly protected MPA that still respects aboriginal and treaty rights. Once submitted, these recommendations were misrepresented in the federal government's regulatory approval process, leading to protest by various First Nations and a halt to final designation. It is recommended that future consensus processes be jointly convened by Canada, BC and First Nations, and include more comprehensive representation from the federal government. In effect, this would be a co-managed consensus process— an experiment with public engagement, which is in keeping with the learning-by-doing

approach endorsed by federal policies for the creation of MPAs.

Evaluation of the Mullen Slough Sub-basin Watershed Management Process, King County, WA

Fiona McNair

Simon Fraser University and the Mid-Puget Sound Fisheries Enhancement Group

The Mullen Slough sub-basin drains 15.5 km² (6 mi.²) of the lower section of the Green River watershed, in south King County, Washington. Currently the sub-basin supports multiple land uses including residential, commercial, industrial, agricultural, and open space. There is strong pressure for development throughout the sub-basin. Issues in the watershed, identified through a past public involvement process and several scientific studies include, flooding, water quality, salmonid habitat, wetland loss, and economic development. King County Surface Water Management Division conducted an in-depth series of studies for the Mullen Slough sub-basin in an attempt to plan and initiate projects to attempt to solve some of the flooding, water quality, and aquatic habitat issues in the sub-basin. The results were published in draft form for internal review within King County in Mullen Slough Capital Improvement Project (CIP) Study and Action Plan. In this report, the CIP process is evaluated by means of a new watershed management framework, created from the main steps and principles of four state and federal watershed management frameworks and supporting literature. Recommendations are made for King County concerning future research and management in the Mullen Slough sub-basin and the usefulness of the new framework is assessed and discussed.

Agency Coordination: The Fraser River Estuary Management Program 1985-2003

Joe Stott

Burrard Inlet Environmental Action Program and the Fraser River Estuary Management Program

Anna Mathewson

Fraser River Estuary Management Program

The Fraser River and its tributaries comprise one of the great river systems of the world. The 155 square kilometre estuarine component of the Fraser is at the heart Vancouver's metropolitan area and is one the most productive salmon rivers in the world. It is a refuge for migratory birds using the Pacific Flyway and is important to the regional economy for goods transport, particularly by the forestry sector. Two port authorities operate in the Fraser River estuary.

The Canadian government is a federal system, where the national and provincial governments have shared interests in the environment and economy. The resulting legislative, regulatory, and policy regime often produces overlapping jurisdictions and competing responsibilities. In recognition

of the need to coordinate this governance regime, and in response to community concerns about environmental degradation and habitat loss resulting from regional growth, the environment ministries from the federal and provincial governments forged a partnership to coordinate their efforts. In 1985 they established the Fraser River Estuary Management Program (FREMP). FREMP has evolved to include six partners-agencies from three levels of government and two federally established port authorities.

The partnership has grown under the premise that a new 'agency' is not the way to provide the coordination required. FREMP is a 'program', jointly funded and managed by the partners who retain their authority as agencies seeking 'made in the region' solutions when laws, regulations and enforcement procedures are in conflict.

Key achievements of FREMP are approval of a comprehensive management tool—the Estuary Management Plan, also known as A Living, Working River and the first monitoring report, which defines a set of indicators to evaluate the effect of the Estuary Management Plan.

Over the years, FREMP has served as a model for innovation in intergovernmental coordination for other regions around the world.

Session 10C—Workshop: DEVELOPMENT OF A CANADIAN BIODIVERSITY INDEX

The Federal/Provincial/Territorial Biodiversity Working Group, whose mandate is to implement the Canadian Biodiversity Strategy, has embarked on a multi-year journey to develop an index which captures the complexity of biodiversity and yet provides a cohesive easy-to-understand message to decision-makers. This workshop introduces you to the results of the first year's work towards development of a Canadian Biodiversity Index. We will be seeking:

- Your critique of the second draft of the framework.
- Your ideas and collaboration on future directions for this project.
- Your participation in the next phase, proof-of-concept testing.
- **Risa Smith**, Environment Canada
- **Malcolm Gray**, BC Ministry of Sustainable Resource Management
- **Greg Jones**, BC Ministry of Water, Land and Air Protection

Session 10D: PACIFIC ESTUARINE RESEARCH SOCIETY (PERS) PRESENTATIONS

Baseline Monitoring: Planning, Design, and Prediction for Estuarine Habitat Restoration

W. Gregory Hood, Steve Hinton and John Klochak

Skagit System Cooperative

Baseline monitoring is often neglected in habitat restoration. In a case study from the Skagit estuary (Washington, USA), we demonstrate how baseline monitoring can be used to determine historic conditions, to plan and design for habitat restoration, and to make predictions about vegetation recolonization and likely fish and wildlife usage of the restoration site. We used GIS analysis of historic aerial photos and found that, over the past 50 years, habitat loss occurred both inside and outside of dikes constructed to convert estuarine marsh to agriculture. We used LIDAR to measure the topography of the lower Skagit Delta, simultaneously sampled vegetation and groundtruthed the LIDAR with 2-cm resolution GPS, and used the GPS data to develop an empirical predictive model of estuarine vegetation distribution based on topography. Soil pore-water salinity was also mapped, but found to be a secondary predictor. The vegetation distribution model was linked to the LIDAR model to develop predictions for vegetation colonization after dike removal. Prediction is important because it facilitates planning and management and it also links the restoration and monitoring effort to the scientific method: predictions derived from baseline monitoring are the hypotheses that are tested by implementation of the habitat restoration design.

The Impact of Shoreline Armoring on Upper Beach Fauna of Central Puget Sound

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School of Aquatic and Fishery Sciences

Jim Brennan

Department of Natural Resources

In Puget Sound, the supralittoral zone—the area above mean higher high water (MHHW) influenced by splash and extreme high tides—produces intertidal and terrestrial invertebrates that are prey for outmigrating juvenile ocean-type salmonids. However, extensive shoreline armoring may have negatively affected production in this zone by truncating or eliminating upper beach and riparian habitat. This study compared adjacent altered and natural beach stretches at four sites in central Puget Sound. To assess invertebrate assemblages in the supralittoral zone, two sampling schemes were employed: insect fall-out traps captured terrestrial and shore insects originating from backshore vegetation and beach wrack; and sediment cores were taken to collect invertebrates (e.g. gammarid amphipods, annelid worms, insect larvae) associated with sediments and deposited wrack. Natural beaches had higher

abundances and greater taxa richness in both fall-out traps and benthic cores than did armored beaches. Because juvenile salmon captured in the nearshore often have high proportions of beach and terrestrial insects, these data underscore the importance of maintaining more natural beaches and shoreline vegetation, and suggest that habitat restoration to recreate natural beach processes is important in recovering important lost biological function of Puget Sound beaches.

Invertebrates Transported to the Strait of Georgia and Juan De Fuca Strait by Ballast Water: Where do They Come From and Where do They Go?

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Jeff Cordell

School of Aquatic and Fishery Sciences, University of Washington

Max Larson

Triton Consultants

Mike Foreman

Fisheries and Oceans, Science Branch, Institute of Ocean Sciences

Stacey Ong and Beth Piercey

Fisheries and Oceans, Science Branch, West Vancouver Laboratory

Mike Tarbotton

Triton Consultants

In a project assessing the colonization risk of non-indigenous species (NIS) in ballast water organisms, the originating locations and identity of flora and fauna being brought into the Strait of Georgia were determined using indirect and direct methods. A database provided by the Vancouver Port Authority (VPA) from 515 ships enabled us to plot the start and end positions where ballast water exchanges took place in the north Pacific Ocean. The lines joining the start and end positions, which were called exchange transects, were on average about 400 km long, and were located in diverse water masses of the north Pacific. We also investigated changes in invertebrate assemblages before and after mid-ocean exchange. Invertebrate communities were different before and after exchange but because the exchange process was relatively inefficient for some taxa, a few coastal organisms were likely always present after ballast tanks were flushed. We also obtained data from biological samples obtained from ballast tanks aboard ships in Vancouver Harbour. In samples with low salinity (<25 psu), 16 different taxa were found but the non-indigenous calanoid copepod *Sinocalanus* spp was dominant. Forty-nine taxa were found in high salinity samples (>25 psu). Particle-tracking techniques were used to simulate representative trajectories of passive and active ballast water organisms discharged at proposed back up deballasting sites in Juan de Fuca Strait. Under normal conditions, organisms move southward (summer) or northward (winter) in the Shelf Break Current

and only under strong eastward or northward winds are they transported to the Washington or Vancouver Island shorelines.

Acknowledgements: This research was supported by the Environmental Sciences Strategic Research Fund of the Department of Fisheries and Oceans, Canada. We are grateful to the Vancouver Port Authority and the owners of MS Skaugran for their cooperation and assistance.

Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*) Diet in South Puget Sound, Washington, 1999 – 2002

Joseph Jauquet

Department of Fish and Wildlife

This study explored coastal cutthroat predation of salmon eggs and fry, and the ecological implications of this behavior.

From July 1999 to April 2002, 115 coastal cutthroat were captured by catch-and-release angling in South Puget Sound. 94 stomach samples were analyzed. Wet weights of diet items were salmon eggs and chum salmon (*O. keta*) fry (46%), other non-salmon fishes (23%) and polychaetes (12%). Invertebrates (amphipods, isopods, shrimp and clam necks) constituted 17%, and other items 2%. The most important non-salmon fishes in the diet were shiner perch (*Cymatogaster aggregata*), Pacific herring (*Clupea harengus pallasi*), Pacific sand lance (*Ammodytes hexapterus*) and arrow goby (*Clevelandia ios*). Cutthroat length when salmon were present and not present, was not significantly different (Chi-square = 0.11, 2 df). Apparently, coastal cutthroat preferentially select salmon eggs and chum salmon fry when they are present, despite the abundance of alternative food items, and shift to these alternative items at other times.

Increased fitness and fecundity of coastal cutthroat is likely the result of successful life history traits, such as interspecies feeding. Setting ecologically-based escapement goals for Pacific salmon could support coastal cutthroat population growth.

STRATOGEM—The Strait of Georgia Ecosystem Project

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The Strait of Georgia is a highly productive, semi-enclosed, marine ecosystem that has undergone considerable changes in recent years. Surrounding populations and their sewage have increased, as have commercial (e.g. fishing and shipping) and recreational usages (e.g. boating and sport-

fishing). There have also been significant changes in the marine ecosystem of the Strait of Georgia. STRATOGEM (www.stratogem.ubc.ca) is an attempt to understand the links between the lowest levels of biological productivity in this Strait and the physical dynamics of the system. By tying together a 3 year monitoring program of monthly multi-parameter full water column sampling over the southern Strait with a continuous monitoring program of surface properties from ferries and computer models of the circulation and biological dynamics we hope to come up with some idea about what is going on.

Quantifying the Impacts of Tide Restrictions in Salt Marshes of Northern Puget Sound

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Salt marshes in Puget Sound have experienced a long history of hydrologic alterations for agriculture and development; however, the ecological impacts of these modifications have not been quantified. This project compares insect, vegetation, and fish assemblages in tide restricted and natural salt marshes of Island County, Washington. A majority of fieldwork will take place during the spring and summer of 2003. Using aerial fallout traps, we will characterize insect abundance, composition, and biomass from distinct vegetation assemblages at each marsh. Given the importance of coastal wetlands for juvenile salmonids, particular emphasis will be placed on common salmon prey taxa. Ancillary data on vegetation composition and physical factors will be collected at multiple scales, to help explain insect assemblage patterns. Fish will be sampled in the main marsh channels during tidal exchange.

Preliminary results from pilot data suggest that similar insect taxa occur at all marshes: flies (esp. ceratopogonids, chironomids, ephydriids), mites and ticks, hemiptera, wasps (esp. chalcids), and thrips were particularly common. Differences in insect abundance and composition exist among marshes; however, they are not readily attributable to hydrologic alterations. Forthcoming data collection and analysis should provide a better understanding of factors controlling insect assemblages in these human-impacted systems.

Session 10E—Workshop UNDERSTANDING TRENDS IN MARINE BIRD ABUNDANCE

This session will discuss the nature of observed declines in marine birds, current understanding of causal factors and research needed to better understand these factors.

Session 10F: HUMAN IMPACT OF THE NEARSHORE ENVIRONMENT

Weight of Evidence and Path Analysis Applied to the Identification of Causes of the Cherry Point Pacific Herring Decline.

Wayne G. Landis, Emily Hart Hayes and April M. Markiewicz

Western Washington University

A classic problem in environmental decision making is the estimation of the causes of impacts observed in aquatic populations and communities at regional scales. We applied a weight of evidence (WoE) and path analysis approach based upon our relative risk model in order to estimate the cause of the decline of the Cherry Point Pacific herring. This WoE approach is based upon a risk assessment type conceptual model in order to link the paths of potential sources of stressors to the effects seen in the population. Ranking criteria and regressions are used to assign weights to the potential sources and stressors. A Monte Carlo analysis is applied to represent the uncertainty in each of the ranks, correlations and filters and to estimate the uncertainty of the analysis. This technique results in a series of multinomial distributions representing the likelihood of a stressor causing an impact. In the case of the Cherry Point herring, climate change, habitat alteration and contamination at a landscape scale were identified as important stressors. This case study demonstrates that a clearly derived and quantified WoE and path analysis is a useful approach to investigating casual links at regional scales.

Effects of Shoreline Modification on Spawning Habitat of Surf Smelt (*Hypomesus pretiosus*) in Puget Sound, Washington

Casey Rice

NOAA/NMFS

The surf smelt (*Hypomesus pretiosus*) is an ecologically and recreationally important "forage fish" that occurs throughout Puget Sound and spawns on gravel- sand beaches in the upper intertidal zone. Shoreline armoring and vegetation removal are two of the most prevalent and severe anthropogenic disturbances in nearshore environments. This pilot study compares an armored, unvegetated beach with a natural, vegetated beach in terms of several physical environmental variables, total surf smelt embryo abundance, and live versus dead embryos. At a tidal height of approximately MLLW+12ft during the period of July 16-20, 2001, the modified beach had significantly lower mean relative humidity, and higher mean light intensity, air temperature, and substrate temperature. Particularly striking were differences in substrate temperature, which, on the natural beach, ranged from 12.1°C to 18.2°C with a mean of 14.°C, and on the modified beach ranged from 12.5°C to 29.4°C with a mean of 18.5°C. Although not significantly

different statistically, the proportion of live embryos and total embryo abundance at the altered beach were approximately half that of the natural beach. Expanded, systematic field studies combined with controlled laboratory experiments could build on this and historical information to provide critical data on the biological effects of altered shoreline habitats.

Monitoring Puget Sound Forage Fish and Habitat: Lessons from the Redondo Seawall Reconstruction Mitigation and Monitoring Project

James A. Shannon

Taylor Associates, Inc.

William J. Taylor

Objective: The purpose of the monitoring effort was to identify changes to intertidal beach habitat used by surf smelt (*Hypomesus pretiosus*), Pacific sand lance (*Ammodytes hexapterus*), and rock sole (*Lepidopsetta bilineata*) over a five year period resulting from reconstruction of the Redondo Seawall in King County, Washington.

Methods: Monitoring occurred in consecutive years from 1996 to 2000. Five duplicate, random one liter samples of intertidal beach substrate were taken from each of three transects twice a year along the 0.6 kilometer Redondo seawall.

Results: Substrate particle size suitable for forage fish spawning (substrate 1/16-1/4 inch in size) and fish eggs were present in each years beach substrate samples. However, the reconstructed seawall has changed the composition of substrate at all transects compared to baseline monitoring.

Significant conclusions: Intertidal forage fish spawn and beach substrate vary greatly between years and within seasons. Recommendations for future forage fish monitoring projects include: multiple years of baseline monitoring, beach profile surveys should be conducted in the spring after major winter storms have ceased and in the fall before winter storms change beach habitat, and a relationship needs to be developed between size of substrate and forage fish spawn presence.

Broader implications: A standard methodology for future forage fish monitoring projects needs to be developed so this important strand in the Puget Sound food web is better understood.

Assessing Overwater Structure-related Predation on Juvenile Salmon: A Field Study and Protocol for Weighing the Evidence

Gregory D. Williams, Ronald M. Thom, John Southard, Susan Sargeant, David K. Shreffler, Russ Moursund, and Mark Stamey

Pacific Northwest National Laboratory

Large overwater structures have often been cited as potential migratory barriers and areas of increased predation for juvenile salmon migrating along shallow shoreline habitats, although conclusive evidence has not been demonstrated to date in situ. To help resolve this issue, Washington State Ferries (WSF) sponsored directed research to determine whether WSF terminals affect predation on juvenile salmon. We used a combination of standardized surveys, stomach content analyses, and new observational technologies to assess fish, avian, and mammal predation on salmon fry at ferry terminals and paired reference sites during periods of pre- (early April) and peak (May) outmigration. We observed no significant aggregation of potential bird or mammal predators at six ferry terminal study sites. Few potential fish predators were documented in SCUBA surveys, beach seines, or with a Dual frequency IDentification SONar (DIDSON) camera at Mukilteo, our single underwater study location. Only one instance of salmon predation by fish (staghorn sculpin – *Leptocottus armatus*) was confirmed, and this was at the corresponding reference site. A tiered protocol (Minimum/ Recommended/ Preferred actions) was developed for assessing potential predation at other overwater structures. Likewise, recommendations were developed for incorporating design features into WSF terminal improvement projects that could minimize future impacts.

Applying Seattle's Blueprint to Assess and Benefit Chinook Salmon Using the Urbanized Shoreline

Gail Glowacki and Gail Arnold Coburn

Seattle Public Utilities

How are threatened or endangered species managed within an urban city? To answer this for chinook salmon, listed as threatened under the Endangered Species Act, the City of Seattle developed a framework called the Urban Blueprint. The city was geographically divided into five distinct regions based on water body type. Each type requires different assessments and actions to benefit chinook salmon. The marine shoreline, or nearshore, is one geographic category and has been identified as a habitat used by juvenile chinook. However, when and how juvenile chinook use the shoreline and its resources is uncertain. As a local government, Seattle is conducting research to better manage our shoreline for chinook. Scientists at the University of Washington are working with Seattle to address the null hypotheses, juvenile chinook salmon use all marine nearshore habitats equally. The first phase, conducted this summer, developed new sampling techniques for various shoreline habitat types, including large rock beaches, riprap, vertical bulkheads and over-water docks. Next, the shoreline

will be grossly classified and sampling locations picked from these classifications. Sampling will occur in the summer. The results will have broad implications to other marine shoreline areas within, at least, Puget Sound.

Impacts From Human Trampling on Rocky Intertidal Areas in Washington State

Aleta Erickson

University of Washington

Terrie Klinger

University of Washington

Steven C. Fradkin

Olympic National Park

We examined the effects of human trampling on the rocky shoreline of Olympic National Park (ONP), Washington, to determine whether living intertidal resources are negatively impacted by recreational use. We sampled areas that experience high- and low-levels of human visitation and trampling pressure. We recorded percent cover of algae and sessile invertebrates, barnacle scars and bare space, and densities of motile animals. We measured basal diameters of the barnacle *Balanus glandula*, the grazing limpets *Lottia strigatella* and *L. digitalis*, and frond lengths of the fucoid alga *Fucus gardneri*. Preliminary analyses suggest that this coastline is affected by human trampling. Intertidal assemblages in areas of high visitation show reductions in fucoid algal cover and more barnacle scars and bare space than less-visited areas. Barnacle size distributions in the most-trampled areas are skewed toward smaller individuals.

Washington State can expect a 45% increase in total population over the next 30 years. This urban growth will be accompanied by an increasing demand for coastal recreation and consequent resource damage. Results of our research can be used by coastal managers in the Puget Sound and Georgia Basin to understand and offset the effects of human population growth in the region.



2003 GEORGIA BASIN/PUGET SOUND

Research Conference

**Abstracts
of
Poster
Presentations**

Group 1: SPECIES

Observations on Mating of the Giant Pacific Octopus

Roland C. Anderson

The Seattle Aquarium

James A. Cosgrove

Royal British Columbia Museum

Gregory C. Jensen

University of Washington

Kevin O. Lewand

Aquarium of the Bay

While there are documented observations on mating of many octopus species, there are relatively few of each species and fewer still are observations in situ. Because different octopus species may be flexible in their courtship and mating positions, such observations are valuable for comparative studies. We present here observations on mating of *Enteroctopus dofleini* (Wülker 1910), both in situ and in public aquariums. The males used "mounted mating" or "distance mating," using their hectocotylized arms to pass spermatophores. Such flexibility on the part of the male may be advantageous, depending on the females' positions and postures. Matings took a relatively long time, a mean of 245 min (S.D. = 39). There were commonalities in body patterns during mating in both males and females. Males were papillose and mottled reddish brown in color with frontal and mantle white spots visible while females were smooth and generally paler than the males. We suggest that observations of octopus matings should include location, habitat, species, size, relative maturity, position, posture, body patterning and its changes, possible courtship or male display routines, contextual variables about courtship, mating duration, respiration rate, and presence or absence of the arch and pump spermatophore transfers. These criteria are presented so observers can make appropriate comparisons between species.

San Juan County Forage Fish Assessment Project: Science and Citizen Involvement

Stephanie Buffum

Friends of the San Juans

This study consisted of a field survey of beaches potentially used for spawning by surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*) in San Juan County, Washington. This was a cooperative study of the San Juan County Marine Resources Committee, the Friends of the San Juans, Washington Department of Fish and Wildlife (WDFD) and UW Friday Harbor Labs. Previous investigations by WDFW had identified spawning on county beaches, but surveys were prematurely terminated. This study extended the surveys on a countywide basis to identify beaches that qualified for protection under the Washington State Hydraulic Code Rules.

Results to date have verified previous results and have extended the amount of known spawning habitat. 19 new surf smelt spawning beaches have been identified, resulting in a total of 32 beaches with documented spawning by surf smelt.

Friends of the San Juans and citizen volunteers are surveying beaches throughout the archipelago to identify which areas are spawning sites for forage fish--a critical food source for a wide variety of species, including endangered or threatened salmon stocks. As a result of surveys to date, a total of 9.71 linear miles of forage fish spawning beach are afforded protection under Hydraulic Code Rules.

Status, Abundance, and Colony Distribution of Breeding Pigeon Guillemots Throughout the Inland Marine Waters of Washington State, as Captured by PSAMP Efforts 1999-2002

Joseph R. Evenson, David R. Nysewander, Bryan L. Murphie and Thomas A. Cyra

Washington Department of Fish & Wildlife

Mary Mahaffy

U. S. Fish and Wildlife Service

The pigeon guillemot is the most widely distributed of the alcids that breed within the inner marine waters of Washington State. The Washington Department of Fish and Wildlife and U.S. Fish and Wildlife Service conducted censuses of guillemot colonies in May 1999 – 2002 to assess their status and population trends in the region. Counts, limited to 3.25 hours after sunrise of any given day, were made from boats at the 120 colonies listed in the Catalog of Washington Seabird Colonies (Speich and Wahl 1989), and at over 300 other colonies not previously documented; these counts covered all the known guillemot colonies within the inner marine waters of Washington. All colonies were counted regardless of colony size, with replicates on at least 2-3 different days. Complete counts of all colonies were made from 2000 – 2002, as not all colonies had been documented by May 1999. For comparing yearly trends, colonies were stratified into localized areas to limit the bias of birds shifting between colonies between years. The average total count of breeding guillemots throughout the region ranged from approximately 14,000 to 16,000 from 2000 to 2002. Habitat types at each colony were documented to assess to their importance to breeding guillemots.

Variation and the Timing and Distribution of Herring Spawn in the Strait of Georgia, British Columbia

D. E. Hay and P. B. McCarter

Fisheries and Oceans Canada, Biological Sciences Branch

Fisheries and Oceans Canada has collected data on the distribution, timing and abundance of herring spawning in the Strait of Georgia (SOG) since the early 1930s. Since

record collections started, many changes in spawning have occurred. Until the mid-1960s catches in a reduction fishery often exceeded 60,000 tonnes. Spawning abundance increased in the 1970s after the reduction fishery was closed and replaced by a roe fishery, with smaller catches and precautionary management. Subsequently, spawn abundance and spawning stock biomass (SSB) reached historically high levels in the late 1990s. Concurrently, spawn distribution became concentrated in northern SOG, especially around Denman Island and the duration of spawning has contracted with fewer early spawns than previous decades. The causes of these changes are uncertain. Anthropogenic impacts, especially fisheries or coastal zone developments, might be implicated but we see temporal and spatial changes in spawning - both in areas with, and without such impacts. Significant environmental changes also are implicated, such as an increase in sea surface temperature (SST). We show a significant correlation between spawn distribution and timing and SST in SOG but such relationships are not convincing because they do not occur in others of the BC coast, subjected to similar SST change. Although the distribution and timing changes are unsettling, the SOG herring population appears to be in excellent condition, with a broadly distributed age structure, near-record high SSB, and good recruitment. The 1999 cohort, spawning as 3-year-old herring in 2002, was largest in 50 years and the second largest recorded.

Mapping Groundfish Distributions in Port Townsend Bay: A Review of 30 Years Data

Barbara Nightingale

Biomes

Pacific cod and other groundfish have been studied in Port Townsend Bay for over 30 years. This report reviews data collected, processed, and mapped on those populations. Maps of population distributions and abundances for each species, based on demersal trawls by Norris from 1991 to 2000, will be presented along with reports on beach seine data on juveniles collected by the Port Townsend Marine Science Center. The beach seine data provides insight into the distribution of juvenile groundfish and salmon in Port Townsend Bay over the past five years. Included in the review are the findings of Port Townsend Bay studies of Pacific cod by Karp in 1977 and Pacific cod, walleye pollock, and Pacific tom cod by Walters in 1984. The mapped results display consistent locations that appear to be species-specific and life-history specific. Thirty species have been mapped for Port Townsend Bay. These include Pacific cod, Pacific tomcod, Snake pricklyback, Pacific staghorn sculpin, greenling, flounder, dogfish, lingcod, English sole, Walleye pollock, Pacific sanddab, skate, Pacific herring, shiner perch, blackbelly eelpout, flathead sole, spotted ratfish, and Blackbelly eelpout.

Trends Observed for Selected Marine Bird Species During 1993-2002 PSAMP/WDFW Winter Aerial Surveys in the Inner Marine waters of Washington State.

David R. Nysewander, Joseph R. Evenson, Bryan L. Murphie and Thomas A. Cyra

Washington Department of Fish and Wildlife

The marine bird component of the Puget Sound Ambient Monitoring Program has conducted comparable winter aerial surveys each December and January 1993-2002, addressing portions of all parts of the inner marine waters of Washington. The primary objectives were monitoring of temporal and spatial trends of selected species. The nine-year effort suggests the following:

- Density indices of most species suggest that some decline is still ongoing, varying by location and species.
- The southern and central portions of greater Puget Sound contained the highest densities and numbers for certain species like scoters, but these areas have also showed the greater degree of decline over the last nine years.
- Scoter species exhibited the largest loss of biomass over this nine-year period.
- Some species like goldeneyes and buffleheads, originally thought to be stable when compared over 20 years in the northern waters, are now considered to be slowly declining when examined throughout the inner waters 1993-2002.
- Harlequin ducks showed a generally stable pattern over the nine-year period. Three merganser species, originally thought to be some of the few sea duck species that had not declined over 20 years, now appear to be undergoing a gradual decline during 1993-2002 periods.

Strait of Georgia, British Columbia: Wintering Area for Harlequin Ducks That Breed Throughout the Pacific Northwest

Cyndi M. Smith

Parks Canada

Constance M. Smith

Simon Fraser University

It is very difficult to track individual migratory ducks between breeding and wintering areas. Since 1989 over 4,000 harlequin ducks have been banded, by various researchers in western Canada and the USA, with uniquely coded colour leg bands. Many of these birds have been resighted at breeding streams and wintering areas. We show that the Strait of Georgia, in particular the area on the east side of Vancouver Island from Qualicum Beach to Quadra Island, is an important wintering area for harlequin ducks from breeding streams throughout the Pacific Northwest. Birds that were banded on breeding streams in Alberta, British Columbia, Idaho, Montana, Oregon and Washington have been resighted in the Strait of Georgia, and birds

that were banded in the Strait have been resighted inland. These connections have been made possible through the cooperation of many researchers and volunteers.

Surf Smelt (*Hypomesus pretiosus*) in Burrard Inlet, British Columbia: Evidence of Recreational Overharvesting?

T.W. Therriault and D.E. Hay

Department of Fisheries and Oceans Canada

Surf smelt (*Hypomesus pretiosus*) occur throughout temperate coastal regions of the Northeast Pacific. Our understanding of the biology, distribution and abundance of this species is poor. Within Burrard Inlet, adjacent to the metropolitan area of Vancouver, small local fisheries have operated for over a century. During the early 1900s most smelt were taken in small, commercial fisheries for local consumption. Since then, commercial fisheries have diminished and have been replaced by a rapidly growing recreational fishery that peaks during spring and summer months on surf smelt spawning beaches. Some of the catch in this unmonitored recreational fishery may enter commercial markets. Because of the many uncertainties associated with this species, concerns about the sustainability have been raised. No previous stock assessments have been made for surf smelt in British Columbia. We develop methods to (1) estimate spawning biomass of based on measurements of spawn deposition and (2) estimate recreational catches based on favourable fishing times, as creel surveys are not available. These analyses indicate that recent surf smelt catches in Burrard Inlet may remove 39% of their potential spawning biomass, a high level for a short-lived, iteroparous species. Coupled with an estimated natural mortality rate of 46%, our analyses indicate that the Burrard Inlet surf smelt population may be overharvested. Reduction in recreational harvest levels and preservation of spawning substrate are identified as priorities for this stock.

Group 2: HABITAT

Backyard Benefits

Ashley Adams, Heather Anderson, Emily Augenstein, Ian Bell, Lisa Cooper, Justin Hellier and Mara Wrede

University of Washington

As urban development alters more land area there is a growing need for research on the ecological contribution of urban residential yards and their ability to play a part in keeping people within the city as opposed to moving to more suburban or rural areas in the Puget Sound. Our research will draw from yards registered with the Washington State Department of Fish and Wildlife's Backyard Wildlife Sanctuary Program (BWS) within Seattle city limits. Fifty BWS yards will be paired according to size and location with fifty traditionally landscaped yards. The two central issues we plan to investigate are ecological services and social services of urban yards.

The main ecological question we will explore is: Does an aggregate area of BWS display higher plant diversity than an equivalent aggregate area of traditional yards? This will be accomplished by identifying and counting plant species, habitat structures, and human-related activity in each yard. Aggregating the species lists and the area of each type of yard will determine if there is a difference in ecological services. Water usage data will be used to sample an economic variable of ecological service. Social service information will be driven by the question: Are owners of BWS more satisfied with urban life than owners of traditional yards? By surveying homeowners we will obtain demographic information, yard maintenance regimes and overall satisfaction with their housing location. The results of this study will serve as a basis for future research on the value of the Backyard Wildlife Sanctuary program and will have implications for urban planners, urban residents, local governments and developers.

Ducks Need Farms but How do Farms Survive With Ducks? A Case Study Integrating Agriculture and Wildlife Habitat in the Lower Mainland of British Columbia

Christine Bishop

Canadian Wildlife Service

Boundary Bay is an internationally significant waterfowl and shorebird overwintering area. Since the terrestrial habitat around the bay has been changed from wet meadow to agricultural lands, there have been conflicts between economic interests of pasture owners and maintenance of high quality terrestrial habitat for waterfowl that consume forage crops during winter. Biologists recognize the need to maintain a thriving farm business in the lower mainland else the area could lose its Agricultural Land Reserve designation and thus important green space for wildlife will disappear to urban development. To address the concerns of farmers and help mitigate the impact of waterfowl on forage crops, Canadian Wildlife Service, Delta Farm Institute, Ducks Unlimited, the provincial agriculture and environment ministries are working together to a) quantify the loss of forage crops to duck grazing (\$60K in 2000-2001) and b) identify factors that influence the degree to which ducks graze certain fields and not others, and use this information to mitigate the duck impacts. It appears that waterfowl prefer orchard grass to tall fescue, fields that are not lazare leveled, and fields that are leased rather than owned by farmers are less likely to be managed to reduce waterfowl impacts.

A Wide Area Rapid Assessment Technique for Benthic Habitats

Michael A. Kyte

Golder Associates, Inc.

Offshore geophysical survey methods provide a rapid and cost-effective tool for environmental assessment of coastal zones, estuaries, rivers, lakes, and other water bodies. Mapping of benthic habitat and subsurface geology by Golder Associates Inc. (Golder), is done from small

vessels of opportunity using an integrated combination of side-scan sonars, single or multibeam echosounders, subbottom profilers, underwater video, and the differential global positioning system (DGPS). Surveys conducted to map submerged aquatic vegetation (SAV) (*Zostera* sp. and macroalgae) using solely underwater video can miss important features such as abandoned outfalls, partially buried cables, recreational vessel mooring anchors, and rock outcrops. In addition, video surveys can misrepresent patchy eelgrass conditions as contiguous beds causing erroneous estimates of areal coverage and habitat value. This can cause problems with alignment, site selection, and impact mitigation planning. A side-scan sonar survey, integrated with video images to verify species composition and signal interpretation and real-time DGPS for precise positioning, provides a comprehensive high-resolution map of actual conditions over a relatively large area. Data acquisition and post-processing to produce a map of surficial conditions requires considerably less time and effort compared to mapping the same area by scuba diver or with underwater video alone. The acquired data and images are directly compatible with commonly used GIS programs. This poster presents results from recent marine geophysical surveys conducted to map and select a route for a proposed fiber optic cable in the San Juan Archipelago, Washington.

Status of Fish Habitat in East Coast Vancouver Island Watersheds (1995-2002)

R.A. Tony Litke and Scott Manning

British Columbia Ministry of Water, Air and Land Protection

Two-thirds of the population of British Columbia resides in the Georgia Basin an area which makes up less than 3% of the total land area of the province. This Georgia Basin area of B.C. has an abundance of small, second-order streams, many which originate in private forested lands, then continue on through agricultural and urban environments, including the Trans-Canada highway. The fish habitat of these streams is severely impacted as a result of these obstacle modifications in many situations. We examine the in-stream habitat of nearly 90 small streams and compare the results to a standard for good habitat established by Federal and Provincial agencies. The results of these series of stream assessments over the past 7 years, indicates problem areas in the stream habitat. We found: excessive sediment, low summer discharge; lack of large woody debris (LWD); stream cover; pool area; and development. We make suggestions to protect or rehabilitate the study streams. The health of east-coast Vancouver Island streams, and the dependent fish populations are at severe risk if these concerns are not addressed.

Garry Oak Restoration Project

Carolyn MacDonald

Municipality of Saanich

The Garry Oak Restoration Project is an example of a municipal partnership initiative promoting protection and restoration of threatened Garry oak ecosystems. The

project is based on 10 restoration demonstration sites on municipal lands, designed to educate local residents about the value and sensitivity of Garry oak ecosystems through hands-on participation in ecological restoration. In support of the Garry Oak Ecosystem Recovery Strategy, the Garry Oak Restoration Project is managed by the Municipality of Saanich in partnership with Environment Canada, the University of Victoria and the Garry Oak Meadows Preservation Society. This municipal program includes education for municipal staff and other decision-makers and works to include Garry oak ecosystems within community planning processes.

The objective of this submission is to provide a model of a municipal/community-level program enabling communication and education for decision-makers and citizens about a threatened ecosystem and the importance of protection and ecological restoration, with the ultimate goal of creating community-wide stewardship. The results of this program, started in 1999, have included the establishment of a Restoration Management Plan preceded by vegetation, wildlife and soil inventories; establishment of a community volunteer program including active restoration and monitoring; research partnerships; educational tools including a website and displays; and a partnership option to support other local restoration projects. The success of this program has included support and encouragement of further restoration and education programs within the municipality and as a model for other municipalities.

Urban and Agricultural Encroachment onto Fraser Lowland Wetlands—1989 to 1999

Kathleen Moore and Peggy Ward

Environment Canada

Katrina Roger

Environment Canada / Ducks Unlimited Canada

The Canadian Wildlife Service published a technical report entitled "Wetlands of the Fraser Lowland, 1989: An Inventory" which included maps and descriptions of almost 400 wetlands in the settled area between Vancouver and Chilliwack, British Columbia. With funding from the Georgia Basin Ecosystem Initiative, these maps were converted into a current GIS environment, georeferenced to a finer-scale basemap, and then compared to 1999 orthophotos. The purpose was to identify the number and total area of wetlands that have been affected by urban and agricultural encroachment over that ten year period. Results indicate that a number of wetlands have been affected by encroachment and to varying degrees. Despite an increased societal recognition in that period of the importance of wetland ecosystems, they continue to be developed. Although a number of the wetlands experienced only small incursions, these impacts are nonetheless cumulative and have implications for the long-term functioning of these wetlands, many of which are just remnants of what was lost over the last century. The poster will include maps and statistics indicating the affected wetlands, as well as before and after photos.

Puget Sound Nearshore Ecosystem Restoration Program: Program Overview, Puget Sound Conceptual Model and Guiding Principles

Thomas Mumford

Puget Sound Nearshore Ecosystem Restoration Program

Fred Goetz

USACE

Hugh Shipman and Jan Newton

Department of Ecology

Randy Shuman and Jim Brennan

King County Department of Natural Resources

Charles A Simenstad

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Curtis Tanner

US Fish and Wildlife Service

Doug Myers

Puget Sound Action Team

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U.S. Geological Survey

The Puget Sound Nearshore Ecosystem Restoration Program's objective is to develop a plan for restoring nearshore habitat of Puget Sound for the benefit of biological resources and the integrity of the ecosystem. The authors, known as the Nearshore Science Team, purpose is to provide broad scientific guidance to the program. The overall program is described. The first two products are presented: (1) a conceptual model that describes natural functions and processes within the nearshore environment that support salmon and other key species, and describe how these processes interact with human uses. While the conceptual model focus on the nearshore, it recognizes connections to upland, watershed and offshore systems for potential inclusion in cross system comparisons, and (2) Guiding Principles (GP) are that guide all aspects of the Program, including providing the context to all actions taken, their planning, design, implementation, and adaptive monitoring and evaluation. These GPs set the sideboards of what can be studied and where and how protection and restoration actions should take place. The GP's focus on ecological concepts critical to nearshore ecosystem restoration and conservation.

Evaluation of Methods to Increase Light under Large Overwater Structures

Susan L. Sargeant, Ronald M. Thom, Heida L. Diefenderfer, Amy B. Borde and John A. Southard

Pacific Northwest National Laboratory

To address resource agency concerns about potential impacts of ferry terminal expansion on habitat functions and resource use of nearshore areas, the Pacific Northwest National Laboratory, in partnership with the Washington

State Department of Transportation, conducted field trials with several products that promote light passage through dock structures. Photosynthetically active radiation (PAR) measurements were compared with known minimum requirements for survival of eelgrass, *Zostera marina*, which provides critical habitat for the federally listed chinook salmon, *Oncorhynchus tshawytscha*. PAR measurements were also related to what is known about the effects of light on juvenile salmonid feeding and passage under overwater structures. In general, the products predicted to provide the most to the least light were the grating, SunTunnel, metal halide greenhouse light, and prisms. All the light technologies tested could provide enough light for eelgrass underneath a ferry terminal, though multiples of some devices would be required. Because less light is required for fish to feed than for photosynthesis, any of the products would provide enough light for juvenile salmon to feed under the structure. The number and placement of these devices could be arranged to maximize light penetration for particular purposes in different situations.

Group 3: AQUATIC NUISANCE SPECIES

Establishment of a Long-term Monitoring Program in Padilla Bay to Determine the Effectiveness of Chemical Controls in Returning Mudflat Habitat to Native Condition After *Spartina alterniflora* Removal

Donna Ball and John Rybczyk

Western Washington University

The unique ability of *Spartina* to alter mudflat habitats in Pacific Northwest estuaries raises the question of how sediment habitats are impacted over various temporal scales after *Spartina* removal. This study attempts to characterize habitat impacts of *Spartina* removal on Dike Island, in Padilla Bay, Washington, through monitoring of sediment dynamics at *Spartina alterniflora* eradication sites.

Monitoring of sediment dynamics using Surface Elevation Tables (SET) and feldspar marker horizons began in the summer of 2002, with the goal of establishing long term monitoring sites to research effectiveness of chemical controls in returning mudflat habitat to native conditions after *Spartina* removal. Ongoing research hopes to provide critical information in determining effectiveness of *Spartina* control methods and management objectives for *Spartina* removal in Padilla Bay and other estuaries in the Pacific Northwest.

Recruiting Recreational Divers to Monitor Aquatic Nuisance Species (ANS) in Puget Sound

W. Lauren Mark and Andrea E. Copping

University of Washington

Recreational divers have the potential to act as important sentinels in the search for introduced marine and freshwater species within the intertidal and subtidal areas of Puget Sound and the Straits of Georgia. Investigators at the Washington Sea Grant Program (WSGP), in partnership with the Puget Sound Action Team and the Environmental Protection Agency, recruited recreational divers for training in the recognition and reporting of non-native species. Working with the largest local dive publication, Northwest Dive News, and several local area dive organizations, interpretive centers and dive clubs, we held a series of workshops in locations throughout Puget Sound. The workshops introduced divers to the concept of native and non-native species, described the impacts of invasive introductions, and provided them with materials to aid in the identification of ANS. Divers are provided with printed information and identification guides developed by WSGP including a waterproof card that can be used with the divers' slates underwater.

WSGP created an on-line reporting form to allow divers to log dives in local waters and to report sightings of possible ANS. WSGP staff monitor the reports and alert state Fish and Wildlife officials who can follow up on the sightings.

Group 4: TOXICS – BIOTA AND SEDIMENTS

Sublethal Impacts of Copper on Olfaction and Olfactory-mediated Behaviors in Juvenile Coho Salmon (*Oncorhynchus kisutch*)

David H. Baldwin

Northwest Fisheries Science Center

Jason F. Sandahl

Oregon State University

Jana S. Labenia and Nathaniel L. Scholz

Northwest Fisheries Science Center

Copper is one of the most frequently detected trace elements in surface waters from agricultural and urbanized watersheds. Here we evaluated the sublethal effects of short-term copper exposures on the olfactory neurophysiology and olfactory-mediated behaviors of juvenile coho salmon. Recordings from the olfactory epithelium (electro-olfactograms) were used to measure the inhibitory effects of copper on the responses of olfactory receptor neurons to natural odorants (amino acids, the bile salt taurocholic acid, and a conspecific skin extract). Copper reduced the responsiveness to all odorants within 20 minutes of exposure. The inhibitory effects of copper

were dose-dependent and they were not influenced by water hardness. Toxicity thresholds for the different receptor pathways were determined using the benchmark dose method and found to be similar ($\sim 6 \mu\text{g/L}$ total dissolved copper). For salmon, olfactory function underlies a wide range of behaviors that are important for survival, migration, and reproductive success. To address the impacts of copper on salmon behavior, we are currently exploring the consequences of sensory impairment for behaviors that are related to predator avoidance and juvenile survival.

Effects of Nonylphenol on Tail Resorption and Metamorphic Staging in *Rana catesbeiana* Tadpoles

Jennie Christensen and John Richardson

University of British Columbia

Christine Bishop, John Elliott and Bruce Pauli

Canadian Wildlife Service

The main objective of this study was to determine the effects of exposure to nonylphenol (NP) on the process of metamorphosis in bullfrog (*Rana catesbeiana*) tadpoles. We were interested in whether NP influenced the rate at which tadpoles progressed through metamorphosis and whether the exposure influenced the rate of tail resorption in the metamorphs. We also wanted to determine whether NP affected these processes through a possible direct or indirect disruption of thyroid hormone (TH) homeostasis. We tested this by adding 3,3',5-triiodothyronine (T_3) to the treatments. Early stage bullfrogs were exposed for 7 days to NP treatments (234, 468 and 936 $\mu\text{g/L}$) with or without exogenous T_3 . Endpoints were measured on day 0 and day 7. In the absence of T_3 , NP had a significant effect at 936 $\mu\text{g/L}$, where it both accelerated the rate of development and increased tail growth. In the T_3 + NP treatments a significant delay in the rate of cranial transformation and stage of tail resorption occurred at 936 $\mu\text{g/L}$ of NP. The rate of limb development was not affected by NP in the presence of T_3 . Overall, our results show that NP may be indirectly inhibiting thyroid hormone, thereby affecting tail resorption and some aspects of metamorphic staging.

Trace Metals Concentrations in Storm Water Runoff from Major Bridges in the Seattle Area

Frank Colich

Frontier Geosciences Inc.,

Stormwater runoff is a leading cause of trace metals pollution of water bodies in the Seattle area, resulting in a degradation of aquatic habitats. Runoff from bridges is discharged directly into their respective underlying water body without any prior pretreatment. Samples of bridge runoff were collected using clean techniques (EPA Method 1669) at different bridges around the Seattle area. Concentrations of trace metals were measured from samples collected at both low and high traffic volume times at the Hwy 520 Floating Bridge, the Aurora Bridge, and the West Seattle Bridge. Trace metal concentrations from a Mercury Deposition Network (MDN) rainwater collection station was documented during the collection times to account

for any trace metals influx from precipitation. Results showed elevated concentrations of metals, especially copper and zinc, when compared to the water body accepting the discharge. During high-volume traffic times, these concentrations were up to three times higher than at the low traffic-volume times. Areas of further investigation would be to determine the effects of pretreatment or collection of storm water runoff from bridges on the water quality of the underlying waters.

Sublethal Effects of the Carbamate Insecticide, Carbaryl, on Coastal Cutthroat Trout

Jay Davis

U.S. Fish & Wildlife Service

Jana S. Labenia, David H. Baldwin, Barbara French and Nathaniel L. Scholz

NOAA Fisheries

Willapa Bay is a coastal estuary in Washington State that provides habitat for cutthroat trout (*Onchorhynchus clarki clarki*). In the estuary, schools of trout forage in shallow water along beaches, around oyster beds, and in patches of eel grass. Cutthroat trout use the estuary in the summer months when carbaryl, a carbamate insecticide, is applied to oyster beds to control burrowing shrimp populations. Carbaryl is a neurotoxicant that inhibits acetylcholinesterase, an enzyme that hydrolyzes the transmitter acetylcholine at neuronal and neuromuscular synapses. In the present study we assessed whether cutthroat trout can detect and avoid carbaryl in seawater. We also evaluated the effects of carbaryl on acetylcholinesterase activity using exposure concentrations and durations that are representative of conditions in the estuary on the day of pesticide application. We find that carbaryl does not evoke a measurable response from the cutthroat olfactory epithelium, and that animals do not avoid carbaryl-contaminated seawater in two-choice laboratory tests. Six hour carbaryl exposures significantly reduced acetylcholinesterase activity in both brain and muscle in a dose-dependent manner. Therefore, carbaryl applications in the estuary may impair the behavioral performance of cutthroat trout and increase the predation vulnerability of exposed animals.

Exposure of Nonylphenol Ethoxylates and Other Contaminants in Tree Swallows (*Tachycineta bicolor*) Breeding Near a Wastewater Treatment Plant

Patti Dods

Canadian Wildlife Service

Although nonylphenol is known to have estrogenic effects in aquatic biota, little is known regarding the exposure of nonylphenol ethoxylates to insectivorous birds. This two-year study examined reproductive success, growth and immunological endpoints in Tree Swallows (*Tachycineta bicolor*) potentially exposed to nonylphenol and other contaminants located in sewage lagoons at a wastewater treatment plant. Tree Swallows breeding next to the Iona Wastewater Treatment Plant were potentially exposed to

high levels of nonylphenol ethoxylates through consumption of emergent insects breeding in the sewage lagoons. The results of the study showed significantly reduced clutch size in the population breeding at Iona Island in both years of study. Fledging success was significantly lower in the potentially contaminated population in the first year of data collection; however, no difference was detected in the second year of study. Other factors besides contaminant exposure that may influence reproductive success, such as diet composition and frequency of feeding trips, were not found to differ significantly between sites. Levels of nonylphenol ethoxylates detected in sediment, insects and tree swallow liver samples varied between the two years of study. This study reinforces the importance of multiple-year studies when carrying out wildlife toxicology research.

PCB Aroclor Concentrations in Puget Sound Sediments

Margaret Dutch, Sandra Aasen and Ed Long

Washington State Department of Ecology

Concentrations of 8 PCB Aroclors were determined for 300 sediment samples collected throughout Puget Sound during 1997-1999 for joint monitoring conducted by the Washington Department of Ecology and the National Oceanic and Atmospheric Administration. Aroclors 1254 and 1260 were detected in 100 and 87 of the 300 samples, respectively. Aroclors 1242, 1248, and 1268 were detected in 10, 10, and 4 of the 300 samples, respectively, while three others, 1016, 1221, and 1232, were never measured above practical quantitation limits. The highest individual and mean values for total PCB Aroclors were measured in samples collected from the Whidbey Basin and Central Puget Sound regions. Spatial patterns and gradients clearly indicate that the highest PCB Aroclor values occurred in the urban/industrialized embayments of Everett Harbor, Elliott Bay, Commencement Bay, and around Bainbridge Island, and tend to diminish in value from the head to the mouth of these embayments. Total PCB Aroclor values at 21 of 300 stations exceeded the Washington State Sediment Management Standard (SMS) value of 12 ppm oc (Port of Everett, Elliott Bay and the Duwamish, Thea Foss and Hylebos Waterways, and Sinclair Inlet). One value exceeded the Cleanup Screening Level of 65 ppm oc (East Harbor Island).

PCB Congener Concentration in Puget Sound Sediments

Margaret Dutch, Sandra Aasen and Ed Long

Washington State Department of Ecology

Concentrations of 19 PCB congeners were determined for 300 Puget Sound sediment samples collected during 1997-1999 for monitoring conducted by the Washington Department of Ecology and the National Oceanic and Atmospheric Administration. The four congeners most frequently detected were 101, 118, 138, and 153. Five others, 8, 18, 77, 126, and 195, were detected least frequently. Highest individual and mean values for total PCB congeners were measured in samples collected from

Whidbey Basin and Central Puget Sound regions. Spatial patterns and gradients clearly indicate that highest PCB congener values occurred in the urban/industrialized embayments of Everett Harbor, Elliott Bay, Commencement Bay, and around Bainbridge Island, and tend to diminish from the head to the mouth of these embayments. Total PCB congener values at 14 of 300 stations were equal to or exceeded the nationally derived Effects Range Median (ERM) sediment guideline value of 180 ppb, indicating a probable-effects range within which biotic effects would frequently occur (Port of Everett, Elliott Bay and the Duwamish, and Thea Foss and Hylebos Waterways). Values at 48 stations were > the Effects Range Low (ERL) guideline value of 22.7 ppb, but < the ERM, indicating a possible-effects range within which effects would occasionally occur.

Effects of Copper on Mechanosensory Structures in Developing Fish Embryos and Larvae

Tiffany Kao and Nathaniel Scholz

NOAA Fisheries

Copper is a common contaminant in urban stormwater runoff. There are many sources of copper in urban watersheds, including residential pesticide use, vehicle brake pads, and stormwater drainage systems. It has previously been shown that copper is highly toxic to ciliated sensory neurons in fish, and the periodic transport of copper to surface waters could impair the health and survival of salmonids or other fish species that spawn in urbanized habitats. In the present study we use the zebrafish (*Danio rerio*) as a surrogate model to examine the effects of copper on the development and function of the lateral line system in fish. We used in vivo fluorescent imaging in combination with a vital dye (DASPEI) that stains ciliated lateral line neurons and neuromasts to examine the impacts of copper on the development of ciliated mechanosensory neurons. We find that short-term copper exposures at concentrations that are representative of urban stormwater runoff in Puget Sound streams are sufficient to induce cell death and a loss of peripheral sensory structures in developing zebrafish. Consequently, short-term exposures to copper in urban stormwater runoff may impair a sensory system that plays an essential role in orientation, schooling, and predator avoidance in salmon and other fish species.

Potential Effects of PAH and Temperature on Cherry Point Herring

Michael H. Salazar and Sandra M. Salazar

Applied Biomonitoring

Between 1998 and 2000, three caged mussel studies were conducted in the vicinity of oil refineries along the Cherry Point Reach near Bellingham, WA. In each test mussel survival, bioaccumulation, and growth were measured. The primary purpose of the caged mussel studies was to estimate potential polycyclic aromatic hydrocarbon (PAH) exposure to embryos, larvae, and juvenile herring. The primary purpose of the caged herring embryo studies was

to measure biological effects. The caged mussel studies identified both PAH and temperature as potential stressors on the Cherry Point herring stock. Concentrations of PAH measured in mussel tissues and water temperatures measured along the Cherry Point Reach approached those associated with adverse effects on herring embryo-larval development. However, there are uncertainties in these conclusions due to possible differences in exposure pathways between herring embryo-larval stages and mussels as well as the duration, magnitude, and timing of PAH and temperature exposures for embryos and larvae. Other studies have suggested that factors such as food, predation, disease, overfishing, disease, and habitat loss are the primary cause for the decline in this stock. This poster summarizes the results of the caged mussel and temperature monitoring and discusses some of the uncertainties in associated laboratory and field studies.

A Mussel Watch Approach to Integrate Biomonitoring in the Georgia Basin

Michael H. Salazar and Sandra M. Salazar

Applied Biomonitoring

Several Georgia Basin monitoring programs in the US and Canada are designed to quantify the status and trends in ambient conditions using long-term monitoring approaches. A Georgia Basin Mussel Watch approach is proposed to better integrate the biomonitoring elements of these programs. "Mussel Watch" is a monitoring approach that typically includes measuring tissue chemistry in resident or transplanted bivalves at regular intervals to establish the status and trends in environmental quality. The proposed approach would include measuring other endpoints such as biomarkers and growth to add an effects component to the monitoring. A Georgia Basin Mussel Watch Program would provide a means to focus current individual programs on a more common goal, minimize the costs of data collection and maximize the consistency of the protocols. Other benefits to establishing a basin-wide Mussel Watch program include integration of existing programs with more cost- and services-sharing, consistency with the risk assessment methodology, more emphasis on using other tools in the environmental monitoring toolbox, and addition of previously under-utilized monitoring species. The purpose of this poster is to focus on rationale and methods for establishing a Georgia Basin Mussel Watch Monitoring Program, and to make specific recommendations for implementation.

Electrophysiological Measures of Pesticide Toxicity to the Salmon Olfactory System

Jason Sandahl

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David H. Baldwin

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Jeffrey Jenkins

Oregon State University

Nathaniel L. Scholz

Northwest Fisheries Science Center

Three classes of current use pesticides altered peripheral and central neurophysiological responses of the coho salmon olfactory system to two natural odorants (L-serine and taurocholic acid). Juvenile salmon were exposed for seven days to 0.625 to 5.0 mg/L chlorpyrifos (organophosphate), 0.05 to 0.20 mg/L esfenvalerate (pyrethroid) or 5.0 to 20 mg/L copper (metal), and in-vivo field potential recordings were then measured from the olfactory epithelium (electro-olfactogram, EOG) and the olfactory bulb (electro-encephalogram, EEG), simultaneously. The pesticides altered odorant-evoked responses by reducing peak amplitude of the EOG and EEG, and/or by inducing post-stimulus burst activity measured in the olfactory bulb. Collectively, these data indicate that the salmon olfactory system is vulnerable to the neurotoxic effects of certain current use pesticides, and that in vivo electrophysiological recordings can provide a sensitive, quantitative, and reproducible measure of sensory impairment under environmentally realistic exposure conditions.

Rapid Phenotypic Screening in Zebrafish: A Model for Identifying Developmental Toxicity in Native Fish Species

Carla M. Stehr, Kathi A. Lefebvre, Tiffany Kao, John Incardona and Nathaniel L. Scholz

NOAA Fisheries

Many native fish species in Puget Sound and the Georgia Basin are exposed to anthropogenic contaminants and marine biotoxins during early stages of development. The impacts of degraded water quality are a particular concern for at-risk stocks such as herring and Pacific salmon. However, detailed developmental investigations are difficult because precise staging and molecular tools have not been worked out for native species. Moreover, marine fish embryos are often difficult to obtain and rear under laboratory conditions. To address these logistical difficulties, we are using the zebrafish (*Danio rerio*) as a model system for rapid, high throughput phenotypic screens of fish embryos and larvae. Zebrafish are an important system for biomedical research, and there is now an array of molecular and genomic tools available for developmental studies. We are adapting phenotypic screens that were originally used to identify developmental mutants to evaluate the effects of toxins and toxicants on sensitive life history stages of teleosts. These screens fall into three categories:

- (1) Anatomical
- (2) Physiological

- (3) Behavioral.

Our goal is to use zebrafish to identify specific pathways of developmental toxicity for common contaminants, and then validate the findings in native species of concern.

Organic and Heavy Metal Contaminants in Eggs of Caspian, Least and Forster's Terns from Western United States Colonies

Christopher W. Thompson

Washington Department of Fish and Wildlife

Mary Mahaffy

U.S. Fish and Wildlife Service

Terry Adelsbach, Arthur Holden and Jianwen She

Department of Toxic Substances Control

Concentrations of contaminants have been measured for decades and used as meaningful indicators of the relative health of populations of various species, and the ecosystems in which they live, across both space and time. The goal of this study was to assess aspects of the current health of nearshore coastal marine waters of the western United States by measuring various organic and heavy metal contaminant levels in appropriate trophic-level species. Seabirds are a particularly useful group of species to assess ecosystem health at various temporal and geographic scales because many species feed at high trophic levels, are long-lived, and typically are faithful to their breed sites. Therefore, in this study, we measured some heavy metal and organic contaminants in three upper trophic level obligate fish-eating seabirds (Forsters, Least and Caspian Terns) at various colonies along the west coast of the United States to: (1) assess differences in contaminant levels among different geographic breeding populations, and (2) compare these levels to historical contaminant data for these species. Specifically, we measured various polychlorinated biphenyls (PCBs), organochlorines, dioxins, a relatively new class of compounds of concern known as polybrominated biphenyl ethers, and three heavy metals (mercury, arsenic and lead). These data will be presented and discussed.

Group 5: NUTRIENTS, PATHOGENS AND HABs

Evaluating Status and Trends in Fecal Pollution from Shellfish Growing Areas in Puget Sound and the straits of Georgia and Juan de Fuca

Timothy A. Determan

Washington State Department of Health

Procedures used by the Washington State Department of Health to classify shellfish beds were adapted to evaluate status and trends in fecal pollution impact. The analysis for the year ending 2001 included status of 95 shellfish growing areas in Puget Sound and the straits of Georgia and

Juan de Fuca. A fecal pollution index (FPI) was developed to estimate impact from fecal pollution. Sixty-four areas showed negligible impact (FPI was 1.00 or less). Thirty-one areas show significant impact (FPI was greater than 1.00). The impacted areas were ranked by the FPI. Trend analysis showed evidence of improvement in several growing areas following focused and rigorous remedial action.

The Washington State Department of Health (DOH) monitors biotoxins in shellfish from Washington state waters to protect shellfish consumers from harm. Each year DOH analyzes spatial and temporal trends in Paralytic Shellfish Poisoning (PSP) toxin for the Puget Sound Ambient Monitoring Program (PSAMP). Status and trends have been analyzed for ten years of data. For the year ending 2001, PSP levels measured in mussels from 34 Sentinel Monitoring Sites in Puget Sound and the straits of Georgia and Juan de Fuca were sorted into four impact categories (none-high). Twenty-four sites had at least minimal impact. A PSP Impact Factor (based on duration of PSP incident) was used to rank impact. Sites in Hood Canal, Totten Inlet (south Puget Sound), and Westcott Bay (San Juan Islands) were free of PSP in 2001.

Spatial and Temporal Patterns of Paralytic Shellfish Poisoning in Puget Sound and the Straits of Georgia and Juan de Fuca

Timothy A. Determan

Washington State Department of Health

The Washington State Department of Health (DOH) monitors biotoxins in shellfish from Washington state waters to protect shellfish consumers from harm. Each year DOH analyzes spatial and temporal trends in Paralytic Shellfish Poisoning (PSP) toxin for the Puget Sound Ambient Monitoring Program (PSAMP). Status and trends have been analyzed for 10 years of data. For the year ending 2001, PSP levels measured in mussels from 34 Sentinel Monitoring Sites in Puget Sound and the straits of Georgia and Juan de Fuca were sorted into four impact categories (none-high). Twenty-four sites had at least minimal impact. A PSP Impact Factor (based on duration of PSP incident) was used to rank impact. Sites in Hood Canal, Totten Inlet (south Puget Sound), and Westcott Bay (San Juan Islands) were free of PSP in 2001.

The Effects of *Heterosigma akashiwo* Blooms on a Microzooplankton Community

Debbie Erenstone

Western Washington University

The Raphidophycean flagellate, *Heterosigma akashiwo*, is a phytoplankton that forms red tides in both the Puget Sound and the Strait of Georgia. *H. akashiwo* blooms are known for their detrimental effects on the Atlantic Salmon Fish farming in this region. Some studies have shown that these blooms have profound effects on the planktonic community, especially tintinnid ciliates; this is noteworthy as microzooplankton exert significant grazing pressure in many coastal systems. This field study monitored

environmental conditions, autotroph growth rate and microzooplankton grazing rate within the Burrard Inlet near Port Moody, British Columbia, from June 12 until July 11, during which two *H. akashiwo* blooms took place. I used the dilution incubation technique to measure autotroph growth and microzooplankton grazing rates, and then a size-fractionated incubation technique to determine the extent to which different sizes of microzooplankton graze on the plankton community. I also collected and preserved samples for the identification of dominant species in the planktonic community, estimating biomass and monitoring abundance of primarily *H. akashiwo* and microzooplankton grazers. These data will be used to determine the effects of *H. akashiwo* on the microzooplankton community. Preliminary data indicate a decrease in microzooplankton grazing during bloom conditions; however, microzooplankton counts will help reveal whether this is due to a change in the grazer community composition, an overall decrease in grazer abundance, or the behavior or inability of grazers to feed on *H. akashiwo*.

Using Remotely-sensed Sea Surface Temperature Data to Track Movement of the Juan de Fuca Eddy in Association with Pacific Northwest Coast Harmful Algal Blooms

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Battelle Marine Sciences Laboratory

Vera L. Trainer

Northwest Fisheries Science Center

Satellite remote sensing techniques are being used to study the initiation and movement of harmful algal blooms off the coast of Washington State, through ocean feature tracking and analysis. Sea surface temperature data is acquired through the Advanced Very High Resolution Radiometer instrument aboard NOAA weather satellites, and is used to delineate the Juan de Fuca eddy and track the motion of its cold-water masses, which have been associated with elevated levels of the biotoxin domoic acid. Domoic acid poisoning is a health and economic concern for the coastal communities of Washington, causing frequent closures of shellfish harvesting activity. Blooms of the phytoplankton that produce domoic acid, *Pseudo-nitzschia* spp., are thought to form west of the Strait of Juan de Fuca in this semi-permanent eddy bordering Washington and British Columbia, before being transported ashore onto Washington beaches. Remote sensing analysis methods are being used along with oceanographic modeling, and in-situ sampling to develop an understanding of the mechanisms that initiate and transport *Pseudo-nitzschia* cells and domoic acid to the Washington coast. The long-term research goal is development of a forecasting tool for predicting and monitoring future bloom occurrences.

Nitrate Concentrations and Bacteriological Counts in Groundwaters from the Lower Fraser Valley, British Columbia—A Survey

Basil Hii, Stephanie Sylvestre and Mark Sekela

Environment Canada

As part of the Georgia Basin Ecosystem Initiative (GBEI), Environment Canada conducted a survey of groundwaters in 1998 at selected Lower Fraser Valley (LFV) sites. The survey included areas of intensive agricultural use (impacted sites) as well as those with no known agricultural activities (reference sites). Twenty sites (16 impacted and 4 reference) in several LFV aquifers were sampled for nutrients, bacteriological parameters, metals, organic contaminants, and estrogen/androgen screening tests.

This paper will present only nutrient and bacteriological results. Nitrate concentrations were elevated at four impacted sites—two were over 3 milligrams nitrogen per litre (mg N/L) and another two exceeded the Canadian Environmental Quality Guideline for Drinking Water of 10 mg N/L. The nitrate concentrations in reference sites were all < 1 mg N/L. Total and fecal coliform and *Escherichia coli* counts were zero at reference sites and positive at four impacted sites—with total coliform counts ranging from 2 to 1300 colonies per 100 ml.

Washington's Beach Environmental Assessment, Communication and Health (BEACH) Program

Lynn Schneider and Jan A. Newton

Washington State Department of Ecology

The Beaches Environmental Assessment and Coastal Health Act of 2000 was signed into federal law as an amendment to the Clean Water Act. The intent of the BEACH Act is to reduce the risk of disease to users of the Nation's marine recreational waters. Through EPA, grant money is being allocated to states for the development of programs that will monitor pathogens in coastal marine waters used by the public and notify them of potential exposure to microorganisms.

The Department of Ecology is coordinating the development and implementation of a BEACH program for Washington State. Ecology, in collaboration with the Department of Health, many other state, county, and local agencies, and the Surfrider Foundation, is developing written guidance for the monitoring program. Washington's BEACH Program will monitor heavily used marine recreational beaches for *Enterococci*. The BEACH Program will prioritize public marine recreational beaches according to potential pollution problems and input from the public through workshops and surveys, monitoring those most at risk and of high-use. Signage on the beach, a hot-line number, and sample results available via the Web will be used to reduce the risk of disease by notifying the public of conditions potentially hazardous to human health and safety. BEACH monitoring will start in summer 2003.

Best Management Practices to Reduce the Risk of Surface Water Contamination From Manured Agricultural Fields in South Coastal British Columbia

Laurens J.P. van Vliet

Agriculture and Agri-Food Canada

George A. Derksen

Environment Canada

The effectiveness of two Best Management Practices (BMPs) in reducing solid and nutrient transport from agricultural fields were tested over a five year period using runoff plots (slope 3-5). In years 1 and 2, the plots were planted with silage corn and the BMP treatment was intercropping with a relay crop of Italian ryegrass. In years 3 to 5, the plots were planted with orchard grass and the BMP treatment was mechanical soil aeration. In each case, liquid dairy manure was applied following common practices including amount and timing. Common practices are broadcasting manure by splash-plate on corn stubble in the fall (years 1 and 2) and on non-aerated orchard grass (years 3 to 5).

Surface runoff from each storm event was contained in a collection system. The number of runoff events per crop year varied between 13 to 31. Runoff samples were tested for total suspended solids (TSS), volatile solids (VS), TKN, TP, and K.

Over years 1 and 2, TSS load from the intercrop treatment plots was reduced significantly to 2.3 t/ha from 9.0 t/ha for the common practice, an average reduction of 74%. VS load was also reduced significantly by 62% (from 1241 to 474 kg/ha), and nutrient loads were reduced between 31 and 56%. However, the relay crop was not considered effective in reducing contaminant concentrations and load from the early "first flush" events following fall manure application.

In years 3-5, treatment effects were significant for all variables measured. The average reduction in runoff from aeration was 78%, TSS load from aeration was reduced by 69%, VS by 80%, TKN load by 73% and TP load by 31%.

It was concluded that the two BMPs tested were very effective in reducing solids and nutrient loads from manured agricultural fields in South Coastal BC.

Group 6: OCEANOGRAPHY

Basin-scale Seasonal and Interannual Transport Variability and Sensitivity from a Box Model of Puget Sound Circulation

Amanda Babson and Mitsuhiro Kawase

University of Washington

A box model of Puget Sound circulation is used to study seasonal and interannual variations in interbasin volume transports. The model dynamics include conservation of

mass and salt and a vorticity balance. Idealized forcing and mixing functions based on 1990's data are used. Model transports vary seasonally by up to a factor of 3 depending on the basin, with time of peak transports ranging between June and November. The largest seasonal difference occurs in the Main Basin where transport decreases sharply in the fall as river flow increases. This decrease is due to the largest river flow entering seaward of the Main Basin and decreasing the salinity gradient between the Main Basin and Admiralty Inlet. A forcing sensitivity study is able to separate how much of the transport variation is due to river flow and how much is due to Strait of Juan de Fuca (SJF) salinity. River variability has a larger effect than SJF salinity on seasonal transports except in northern Hood Canal and the Main Basin. Interannually, only in the Main Basin does SJF salinity variability have a larger effect than river forcing. Resulting residence times show a high degree of interannual variation, particularly in the Main Basin.

An Interdisciplinary Investigation of Puget Sound Beach Dynamics

David Finlayson, Charles "Si" Simenstad

University of Washington

Hugh Shipman

Washington Department of Ecology

Guy Gelfenbaum

U.S. Geological Survey

As a legacy of Pleistocene glaciation, Puget Sound differs geologically in significant ways from other large estuaries in North America. It is apparent that Puget Sound beaches have ecological, chemical, and physical structure and processes distinct from other systems and that these factors are important to threatened and endangered species, such as Puget Sound chinook and summer chum salmon. However, systematic studies of Puget Sound beaches are unusual and many questions about key processes remain open and unexplored.

The University of Washington, the State of Washington and the U.S. Geological Survey have established an interdisciplinary nearshore research team to examine this unique nearshore environment. On the west coast of Camano Island, we have initiated a comprehensive monitoring program to establish a baseline dataset against which models of nearshore sediment transport, chemical and nutrient cycling, and habitat structure and change can be calibrated. This data presently includes high resolution bathymetric LIDAR across the shoreline, low-altitude air photography, in situ wind and wave recordings, and monthly sediment sampling information. The ultimate goal is to link nearshore dynamics to predictions of ecological responses and to predictions of the consequences of human interruptions of these natural relationships.

Oceanographic Data for the Pacific Northwest Coast from Washington to Northern California: Results from an Undergraduate Research Cruise

Noah L. Halvorsen, James E. Gawel and Cheryl L. Greengrove

University of Washington

Oceanographic data for the Pacific Northwest coast from Washington to Northern California is important for understanding the physical, chemical, and biological factors affecting local fisheries and for constructing models for effective fisheries management. However, current comprehensive large-scale alongshore oceanographic data for the Pacific Northwest coast is minimal. Therefore, regular continuous sampling cruises along this coast would add greatly to the knowledge of local ocean conditions and aid in decision-making for addressing fisheries concerns. In the summer of 2002, as part of an undergraduate course offered by the University of Washington, Tacoma, in an educational partnership with the Sea Education Association of Woods Hole, Massachusetts, physical, chemical, and biological data were collected along a cruise track from the Puget Sound to San Francisco Bay aboard the SSV Robert C. Seamans. Continuous surface data were collected using a flow-through system, while current magnitude and direction were measured by ADCP. In addition, CTD casts were conducted at various locations along the cruise track, and nutrient, chlorophyll-a, and oxygen concentration were measured. The data collected shows (1) evidence of upwelling along the Northern California coast, (2) the signature of the Columbia River plume, and (3) the location of the California Current. Results from this cruise will be compared to historical data.

Seeing the Sound: A System for Learning About Puget Sound Using Model Visualizations and In-situ Field Experiences.

Christian P. Sarason and Frederick R. (Fritz) Stahr

Ocean Inquiry Project

Puget Sound is a complicated estuary, and an excellent place to learn about oceanographic concepts. In a partnership program with educational researchers at the University of Washington, Ocean Inquiry Project (OIP) has created a web-based system for exploring a numerical model of Puget Sound. Since 1999, OIP has involved introductory level oceanography students in field-based research experiences on Puget Sound. OIP participants are primarily community college oceanography classes, who get onto the Sound to sample a number of monitoring stations using a CTD and plankton nets. Using our new model exploration system, students will be able to investigate the Sound before getting into the field, thus getting exposure to additional facets of oceanographic science. The system is available to anyone with access to the Web; using this tool for quick insight into the circulation of Puget Sound will form an excellent precursor to more in-depth investigations, both by interested laypersons and researchers alike.

Finally, the computer-based and field-based curricula will be evaluated in order to compare which approach helps students best learn oceanographic concepts about Puget Sound. For additional information regarding the system, see <http://www.oceaninquiry.org/modelvis/>.

VENUS: A Novel Seafloor Observing System for Straits of Georgia and Juan de Fuca

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Centre for Earth and Ocean Research, University of Victoria

R. Pawlowicz

Department of Earth and Ocean Sciences, University of British Columbia

VENUS is an innovative approach to observing the oceans. Scientific instruments under the sea surface and on the sea floor will connect directly to a data clearinghouse and to the computers of scientists via cables. These cables will provide the necessary electrical power and interactive communication. Synoptic, multidisciplinary observations will be available in real time to participating scientists, resource managers and educators anywhere on the Internet. Scientists will be able to change or start measurements in response to episodic events, from their laboratories, at any hour of the day or night. Deployment is planned for three locations in the Straits around Vancouver Island starting in 2004. The locations will support internationally significant research on a range of topics. Phenomena include the effects of climate change on an important marine ecosystem, the response of a major delta to storm, seismic, and hydrological events, and the processes controlling productivity in a large estuarine system. With VENUS, we take a major step up from the limiting and sparse observations from ships and moored instruments. VENUS has five essential elements:

- (1) Fibre-optic cables providing power and two-way high speed communications.
- (2) Seafloor instrument arrays with a standard instrument suite and study-specific devices.
- (3) Mid-strait vertical profiling packages.
- (4) An archive centre with data management and distribution providing a user interface and long-term access.
- (5) An operations centre to monitor and control all subsea and shore station elements.

The system will be capable of future expansion at two levels: researchers or instrument developers will be able to attach new or complementary equipment; and the data distribution and archive will allow links or integration with existing and planned ocean databases. The VENUS system design is partially based on the work of the NEPTUNE System Engineering Team that is designing a 3000-km /30-node observatory network proposed off the west coast of North America.

Group 7: MODELS/TOOLS

PRISM Cruises: Developing a Database to Evaluate Interannual Variability in Puget Sound. Part 1: Temperature and Salinity 1998-2002

Jonathan Kellogg, Noel Gray, Mitsuhiro Kawase, Mark Warner and Jan Newton

University of Washington

The Puget Sound Regional Synthesis Model (PRISM) was established in 1998 to develop a comprehensive baseline model for the natural and human environment of the Puget Sound drainage basin. Our work focuses on understanding estuarine circulation through variability in the hydrographic properties. The University of Washington School of Oceanography in conjunction with Washington State Department of Ecology have utilized the R/V Thomas G. Thompson to sample thirty-nine stations in four regions of Puget Sound; Hood Canal, Main, Whidbey and South Basins – as well as the adjacent eastern Strait of Juan de Fuca. The four-day cruises have occurred semiannually in June and December and have resulted in a five-year dataset which includes physical, chemical, and biological measurements of the water column. We examine temperature, salinity and dissolved oxygen concentration and correlate them with climatological factors and physical processes. Upon analysis of this dataset, important changes in the water column stand out. These include tidal refluxing across sills, intrusions of Pacific water, surface salinities influenced by river discharge, and air/sea-surface temperature correlation. Existing and future data will be used to enhance the accuracy of circulation models of Puget Sound.

PRISM Cruises: Developing a Database to Evaluate Interannual Variability In Puget Sound. Part 2: Dissolved Oxygen 1998-2002

Noel Gray, Jonathan Kellogg, Mitsuhiro Kawase, Mark Warner and Jan Newton

University of Washington

The Puget Sound Regional Synthesis Model (PRISM) was established in 1998 to develop a comprehensive baseline model for the natural and human environment of the Puget Sound drainage basin. Our work focuses on understanding estuarine circulation through variability in the hydrographic properties. The University of Washington School of Oceanography in conjunction with Washington State Department of Ecology have utilized the R/V Thomas G. Thompson to sample thirty-nine stations in four regions of Puget Sound; Hood Canal, Main, Whidbey and South Basins—as well as the adjacent eastern Strait of Juan de Fuca. The four-day cruises have occurred semiannually in June and December and have resulted in a five-year dataset which includes physical, chemical, and biological measurements of the water column. We examine

temperature, salinity and dissolved oxygen concentration and correlate them with climatological factors and physical processes. Upon analysis of this dataset, important changes in the water column stand out. These include tidal refluxing across sills, intrusions of Pacific water, surface salinities influenced by river discharge, and air/sea-surface temperature correlation. Existing and future data will be used to enhance the accuracy of circulation models of Puget Sound.

A Tool for Assessing Littoral Habitat Function for Salmon—The Tidal Habitat Model

Jonathan P. Houghton, J. Eric Hagen and Juliet C. Fabbri

Pentec Environmental

The tidal habitat model, or THM, uses the indicator value assessment approach to rate quality of tidal marine and estuarine areas for various ecological functions including salmonid habitat (migration, feeding, osmoregulation, health, predation). By using a scoring system to define baseline or existing habitat function within tidal areas and adjacent uplands, tidal areas can then be rated for their conservation, restoration, and mitigation potential.

Originally developed as the Snohomish Estuary Wetland Integration Plan (SEWIP) model by an interagency panel, the THM was revised in 2000 by an expert panel of agency and tribal representatives to ensure the model structure and output reflect the best available science related to how salmonids use tidal habitat. The original SEWIP was applied to rate habitat enhancement, restoration, and mitigation potential, and to identify high priority restoration projects in the study area. In 2000, the model was used to identify and rate restoration projects in tidal areas within the Snohomish Estuary and Port Gardner. Actions that would be necessary to achieve a 20 percent increase in habitat function were identified and ranked. The THM is now being applied to 160 miles of shoreline in southern Puget Sound as part of Pierce County's salmon recovery planning.

Comparison of Remotely-sensed Images for Identification of Land Cover Types in the Greater Vancouver Regional District

Sarbjee Mann and Kristina Rothley

Simon Fraser University

The need to identify and protect critical natural areas in the GVRD and other rapidly expanding urban areas is urgent. Land cover maps derived from ground-based land surveys and/or the interpretation of aerial photographs are time-consuming to produce and become quickly outdated as the landscape is altered. Instead, the automated classification of satellite images can efficiently generate up-to-date land cover maps. However, given the accuracy required for the land cover maps and the costs associated with obtaining the satellite images, it is first necessary to demonstrate the efficiency and efficacy of this technique. This study compared the accuracy, time, and costs associated with land

cover map development for a 10km x 10km sub-urban test area in Langley, BC based on digital images from three satellite sensors: 1) the Landsat Enhanced Thematic Mapper Plus (ETM+) carried by the Landsat 7 satellite, 2) the Synthetic Aperture Radar (SAR) carried by RADARSAT1, and 3) the IKONOS carried by IKONOS 2. Objectives of the research are: 1) to determine the relative merits of each of the land classification technologies and their applicability to urban settings and 2) to supply local government agencies with data they need to support protection of natural areas in the GVRD.

Developing a Network of Sediment Erosion Tables to Determine the Stability of a Hydrologically Altered Pacific Northwest Estuary Given Sea-level Rise

Sacha Maxwell and John Rybczyk

Western Washington University

Insufficient sedimentation and relative sea-level rise are contributing to coastal wetland loss. Additionally, the eustatic sea-level rise component of relative sea-level rise (RSLR) is expected to accelerate over the next 100 years. In order to sustain elevation, estuaries must accrete vertically at a rate that equals RSLR. In Padilla Bay, one of the largest contiguous sea grass meadows on the Pacific coast, water flow from the Skagit River has been altered such that the ability of the estuary to remain stable in the face of sea-level rise is uncertain. Our purpose is to:

- (1) Determine sediment accretion/subsidence rate within Padilla Bay.
- (2) Project the long-term stability of marsh elevation given eustatic sea level rise.
- (3) Determine how ground cover type (mud flat, *Zostera marina*, *Zostera japonica*) regulates accretion rate.

A recently developed field technique that uses sediment horizon markers in conjunction with a surface elevation table (SET), makes it possible to partition and measure vertical accretion and shallow subsidence. We installed a network of SETs throughout the bay. We will use mean accretion/subsidence rates in conjunction with recent and future sea-level rise scenarios to determine stability of the bay. This monitoring system is pertinent to costal management concerns.

The Abbotsford-Sumas Aquifer: Development of a Transboundary Aquifer Flow Model

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B. Hii

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The Abbotsford-Sumas aquifer straddles the Canadian-U.S. border between the province of British Columbia and Washington State. This unconfined sand and gravel aquifer is considered highly vulnerable to contamination that originates primarily from agricultural land use activities.

High levels of nitrates have been measured in the aquifer, and efforts are being made to alter land use practices and monitoring changes in nitrate levels. This paper reports on collaborative research between Simon Fraser University and Environment Canada to develop a regional groundwater flow and transport model for the Abbotsford-Sumas aquifer. Aquifer architecture has been described using cross-sections constructed from well and bore lithology information, and the identification of aquifer layers was determined primarily from control points for which reliable data were available. Aquifer layer topography was generated using filtered and classified well log information from the BC Water Well Database. Model boundary conditions were identified using aerial photos, but verified in field by considering geology, topographic variation, stream course and evidence of seepage. The flow model will be calibrated and used to simulate transport at a regional scale, thus providing a potentially valuable a management tool for tracking and predicting non-point source contaminant migration over a large scale. The model will also facilitate the development of local small-scale models by providing the larger-scale definitions of important aquifer properties and boundary conditions. Ultimately, the model may be useful for predicting the potential effects of implementing land use scenarios on the groundwater quality. This research highlights the challenges of integrating datasets from different jurisdictions, and attempts to demonstrate that research on transboundary water issues can be successfully undertaken through collaboration and data sharing.

Sensitive Ecosystems Inventory of the Georgia Basin Lowlands

Peggy Ward

Environment Canada

The Canadian Wildlife Service and the BC Ministries of Sustainable Resource Management and Water, Land and Air Protection conducted Sensitive Ecosystems Inventories (SEI) throughout the 8,000 square kilometer lowlands of East Vancouver Island and Gulf Islands (1993-1997) and the Sunshine Coast (1999-2003). This area has exceptionally high biological diversity values, and is home to many rare and endangered plants, animals, and plant communities. Intense development pressure has caused the fragmentation and loss of many of these rare and fragile ecosystems.

The SEIs systematically identified, mapped, and evaluated remnant rare and ecologically fragile terrestrial ecosystems, including wetland and riparian ecosystems, older forests and woodlands, dune, spit and cliff ecosystems, coastal bluffs, and native grasslands. Both hardcopy and digital maps were produced, as were other outreach materials and services.

The SEI information supports regional district and municipal land-use planning processes, the acquisition and protection of critical habitat, park plans, private land stewardship and other conservation strategies, such as the Garry oak Recovery initiative.

An evaluation of this innovative approach to mapping environmentally sensitive areas is underway and will be available early in 2003. The poster will include maps, photographs and statistics describing the effectiveness of this program in influencing conservation-based land-use decisions.

Group 8: MONITORING

Environmental Trends in British Columbia, 2002

Dr. Linda Gilkeson

Ministry of Water, Land & Air Protection, Victoria, BC

Environmental Trends in British Columbia 2002 is published by the provincial government to make credible scientific information on key environmental issues and trends accessible to citizens. This report employs a series of environmental indicators used by provincial, national and international organizations to measure environmental performance, progress towards environmental targets and to alert decision makers and the public to emerging environmental issues. This report is based on the most recent data available at the end of 2001. Indicators based on annual monitoring programs present data from 2000 or 2001, however, dates vary for indicators based on studies that were conducted irregularly or at longer intervals. Experts in the field have reviewed each indicator. The 16 key indicators incorporate 64 separate measures that show the status and sometimes the trends in issues. The information has been grouped into six theme areas: Biodiversity, Water, Stewardship, Human Health and the Environment, Toxic Contaminants, and Climate Change. When read as a package they paint an overall picture of British Columbia's environment, showing important linkages, particularly between human activities and environmental changes.

Mass Marking of Juvenile Chinook Salmon with Florescent Dye: Resurrection of an Old Tool and Potential Applications for Studies in the Nearshore

Michael Mizell

Washington State Department of Fish and Wildlife

Florescent dye spray marking has been used since the 1960s to mark large numbers of juvenile salmonids with an easily detectable mark at low mortality. We felt that this approach could potentially help us answer key questions about the ecology of juvenile chinook salmon in nearshore areas of Puget Sound. However, there was little data on how to mark chinook with this approach, historically used equipment had degraded or been lost, and old sources of pigment had disappeared. In addition, handling chinook and maintaining low mortality is a challenge. As a result, we decided to redevelop this approach specifically for chinook. Best retention and mortality rates were obtained with a setting of 120 PSI sprayed from 19 inches from the fish, shortly after

adipose fin removal, which facilitated pigment entrainment under fish's scales. We were able to mark over 5000 fish an hour. Mark retention was 96%, 48 hrs post marking and handling mortality was <1% by marking chinook > 3 weeks before smolting. Three months post marking, retention had not changed and mortality was no different than unmarked fish. We successfully marked 120,000 juvenile chinook that were released into Sinclair Inlet to gain insight into residence time in the area and patterns of habitat use.

Human Impact Monitoring and Revegetation Efforts along the Littoral Zone of Ross Lake, Washington

Kelly M. O'Neil

Western Washington University

Native communities along the Skagit River have been impacted from human actions. Development of three consecutive dams has converted the Skagit into lake-like habitat. Establishment of Ross Dam, Diablo Dam, and George Dam have inundated a portion of the Skagit River valley, which has displaced and in some cases decimated biotic populations that once thrived along the river. Currently, Seattle citizens use this hydroelectric power at the riparian community's expense. Understanding the magnitude of human impact on this riparian area can lead to an awareness that will reduce man's impact and exploitation of this land.

Increased visitor use of the Ross Lake Recreational Area is compounding this alteration of the Skagit landscape. Ross Lake Multitask team has identified losses of native vegetation cover, incursions of non-native vegetation and the need for plant community restoration work around campgrounds on Ross Lake. The Multitask team has enabled visitors to have hands-on opportunities in contributing to the restoration work. The Multitask team has also coordinated with Seattle City Light by utilizing woody debris in restoration sites that is otherwise disposed of, transforming a waste into a biological resource. Restoration success relies on visitor and land managers understanding of their biomanipulation within this region.

High Rates of Pre-spawn Mortality in Coho Salmon (*Oncorhynchus kisutch*) from Urban Streams in the Puget Sound Basin.

Laura Reed and Katherine Lynch

Seattle Public Utilities

Kit Paulsen

City of Bellevue

Pat Stevenson

Stillaguamish Tribe of Indians

Mark S. Myers, Gina Ylitalo and Nathaniel L. Scholz

NOAA Fisheries

Spawning surveys in some urbanized creeks around Puget Sound have documented high rates of pre-spawn mortality for coho salmon. Acute mortality ranges from 20-90% of the returning adults in these creeks. Juvenile coho and other

species of adult spawners do not appear to be affected. The causal factors have not been identified, but they are likely to be related to water quality. Symptomatic fish exhibit gaping, loss of equilibrium and, in some cases, convulsions. There is no indication from pathological analyses that pathogens or disease is the cause of death. However, preliminary analyses have shown that affected fish have significantly altered brain and bile chemistry. This is consistent with an exposure to hydrocarbons and other contaminants that are typically found in non-point source runoff. Coho pre-spawn mortality may be connected to the increasing urbanization of coastal watersheds, and the National Marine Fisheries Service, City of Seattle, City of Bellevue, Port of Seattle, and the Stillaguamish Tribe are working together to investigate this problem. In the fall of 2002, indicators of contaminant exposure will be compared among pre-spawning coho, juvenile coho, and other species of spawning salmonids in urban and non-urban creeks.

Using Advanced Scientific Diving Technologies to Assess the Underwater Environment

John Southard, Greg Williams, Sue Sargeant, Heida Diefenderfer and Michael Blanton

Pacific Northwest National Laboratory

Scientific diving is an important tool that can provide unique information for addressing complex environmental issues in the marine environment. The Pacific Northwest National Laboratory (PNNL), Battelle Marine Sciences Laboratory uses trained scientific divers in conjunction with advanced technologies to collect in-situ information best obtained through direct observation requiring minimal environmental disturbance. Diving operations are applied to a variety of increasingly important issues throughout Puget Sound, including habitat degradation, endangered species, the effects of overwater structures and shoreline protection, and biological availability of contaminants. For example, advances in underwater communications allow divers to discuss observations and data collection techniques in real time, both with each other and with personnel on the surface. Other examples include the use of digital sonar (DIDSON) an underwater camera used to capture digital images of benthic structures, fish, and organisms during low light and high turbidity levels; the use of voice-narrated underwater video, and the development of sediment collection methods yielding one-meter cores. The combination of using trained scientific SCUBA divers and advanced underwater technologies is a key element in addressing multifaceted environmental problems, resulting in a more comprehensive understanding of the underwater environment and more reliable data with which to make resource management decisions.

Estimation of Macro-algal Cover on a Newly Colonized Rock Reef

Tina Wyllie-Echeverria

Brigham Young University

David O. Duggins and Sandy Wyllie-Echeverria

University of Washington

We set out to measure the colonization and percent cover of a newly constructed bare rock reef by macro-algae. Rocks 1-2 feet in diameter were placed on a subtidal (-15 to -20 MLLW) mud bottom in order to mitigate for loss of macro-algal habitat. Diver video surveys were completed in the spring and summer following construction of the rock reef. After 1 month the rocks remained bare, after 3 months, small tufts of sporophytes were evident, after 6 months approximately 70% of the rock surface was covered by a variety of macro-algal species and this level of cover continued through the following year (September 2002). Cover was estimated from randomly selecting 30 individual frames from the underwater video surveys and assessing the percent cover in each frame. An average cover for the 1000 square foot rock reef was obtained. This method is a quantitative, archival and verifiable method of estimating cover, and can provide a reliable and cost effective method for documenting habitat.

Group 9: GOVERNANCE/MANAGEMENT

Local-level Implementation of Marine Resource Conservation and Protection Projects: An Analysis of the Northwest Straits Commission Progress Towards the Eight Benchmarks

Jenny Hernandez

University of Washington

In 1998, Congress authorized the Northwest Straits Marine Conservation Initiative, providing funding to establish a system of marine resource advisory committees in the Northwest Straits region. The overall goal of the Northwest Straits Marine Conservation Initiative is to reverse the decline of the region's marine resources through sound science and local-level support. The program is authorized for six years, and its progress will be measured by eight benchmarks to determine its reauthorization in 2005.

All seven MRCs focus on conservation priorities and activities in their respective counties. However, each has differences in organization, process and how they achieve the goal of the Northwest Straits Marine Conservation Initiative. The purpose of this study is to investigate the criterion used by the counties in choosing their respective projects. It then analyzes how the MRCs' projects reflect the framework of the benchmarks established by the Murray-Metcalf Commission. In addition, a case study in two counties will explore and analyze how the MRC projects are implemented at the local level. By analyzing

counties that have implemented projects, this study aims to identify the critical elements in the local implementation of projects and identify the issues that are critical to the reauthorization of the Northwest Straits Marine Conservation Initiative.

The Effects of Marine Protected Areas on Larval Rockfish Ecology

Lucie J Weis

University of Washington

Marine protected areas (MPAs) are becoming increasingly popular fisheries management tools. Benefits include the protection of ecosystem structure and function and replenishment of depleted marine populations. Two major assumptions underlying reserves are that a protected population is more productive and that there is a spillover effect into unprotected areas. This 'leakage' is presumably in the form of larvae, juveniles and adults. There is a significant body of evidence on increased abundance, length and weight frequency of adults in protected areas as well as their movement across reserve boundaries. Although larval export is a widely accepted mechanism, there is little empirical research in the literature. I conducted an ichthyoplankton survey during spring 2002 in the San Juan Islands, WA, with 2 objectives: investigate whether larval production is greater in MPAs as compared to unprotected areas and whether dispersal patterns from MPAs can be detected. I have focused my research on rockfishes, a typically long-lived, late-maturing and formerly abundant species group. Preliminary results suggest that rockfish larvae are concentrated nearshore and near MPAs, indicating that larval dispersal may not be as prevalent as MPA theory predicts.

Group 10: CLIMATE CHANGE/AIR QUALITY

Effects of Wind on Air Pollution in the Fraser Valley Transboundary Area

Cassandra Lynn Hiller

Western Washington University

The objective of this study is to investigate the effects of wind patterns on air pollution in the Fraser Valley Transboundary Area. The Fraser Valley is a unique airshed that is densely populated and heavily industrialized. It consists of a narrow canyon at one end and a broad, relatively flat valley bordered by high mountains and the ocean at the other end. Data collected from Environment Canada and will be analyzed using statistics on wind speed versus direction.

I expect to see an increase in air pollution during the calm summer months and a decrease in air pollution during the wet winter months. A decrease in air quality in this region is a trans-boundary issue because it affects northern

Whatcom County and the Fraser Valley Region in British Columbia. The proposed SE2 power plant, to be located in northern Whatcom County, will increase air pollution in the Fraser Valley Region. Broader implications of a decrease in air quality include effects on human health and increased soil pollution.

Relationships Between Ozone and Particulate Matter (PM) Concentrations, and Emissions in the Lower Fraser Valley (LFV), British Columbia

Tracey Parker and Roger McNeil

Environment Canada

Effective air quality management requires an understanding of the impact of regulated emissions abatement measures on reducing ozone and PM concentration levels. To address this objective, the analysis reviews the published historical LFV emissions inventories in relation to ozone and PM concentrations at various sites within the airshed, and estimates the sensitivity of ozone and PM concentration with respect to emissions. Site-specific estimates are derived via multi-variate linear regression methods, relating ozone and PM concentration as a function of meteorology variables, and aggregate tons of pre-cursor emissions (NO_x, VOC and SO_x). The analysis concludes there is spatial variability among the sites considered. Estimating the percentage change in ozone and PM concentration associated with changes in pre-cursor emissions, contributes to our understanding of the source-receptor relationship between emissions and concentration at various sites within the airshed. The impact that abatement measures will have on improving air quality is a key factor for determining the costs and benefits of various air quality initiatives. The relationships obtained in this study will be linked with associated human health benefits to assist in making informed decisions about potential regional air quality standards, which reflect local human population and environmental factors.

Changes in Puget Sound Water and Sediment Quality in Relation to Climate Changes

Valerie Partridge, Jan Newton and Kathy Welch

Washington State Department of Ecology

Significant changes in sediment characteristics and infaunal communities appear that may be related to climate and oceanographic variations associated with local weather conditions stemming from El Niño-Southern Oscillation and/or Pacific Decadal Oscillation forcing. Both marine sediment and water-column monitoring data from the Puget Sound Ambient Monitoring Program were used to examine this relation. Data from monthly water-column sampling (salinity, temperature, dissolved oxygen, nutrients) and yearly sediment sampling (grain size, TOC, chemical contaminants, benthic macroinvertebrates) at ten long-term monitoring locations throughout Puget Sound were integrated and examined. Stations were selected both near and away from river mouths. We postulate that

the magnitude of river flow may be influencing benthic communities. This was suggested by data showing a general correlation between Fraser River flow and the percent fines in the sea-bed sediments at depth near Patos Island in the Strait of Georgia. That relationship was associated with shifts in annelid-mollusc ratios, as well as in the species of annelids that were found. How general this result was will be discussed, along with a discussion of how understanding these relationships is important to monitoring program design and data interpretation.

Modeling Small Particulate Material Using Neural Network Models

Jon Y. Wang, Ed Lord and Alex Cannon

Environment Canada

Studies have shown that neural network models have the potential to incorporate complex, nonlinear relationships between predictors can provide modest improvements over regression models in a forecasting context. Using data from the Greater Vancouver Regional District air quality monitoring network, ensemble neural network models have been developed to forecast summertime particulate matter (PM₁₀) at nine coastal stations in the Lower Fraser Valley of British Columbia. Potential predictors were gathered from studies of the meteorological and environmental conditions surrounding episodes of high PM₁₀ concentrations in the Lower Fraser Valley between 1994 and 2000. Actual predictors were selected using a modified Generalized Additive Model (GAM) sensitivity analysis procedure. The final models for daily maximum 1-h, 3-h, 6-h, 8-h, and 24-h average PM₁₀ concentrations for each of the stations were developed using ensemble neural network techniques and verified on data from the summer of 2001 and 2002.



2003 GEORGIA BASIN/PUGET SOUND

Research Conference

**Biographies
of
Presenters**

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Tim Abbe is the Director of River Science and Geomorphology at Herrera Environmental Consultants in Seattle. He has 16 years of experience in geology and water resources and is a licensed geologist in Washington, Oregon and California. He received his doctorate in fluvial geomorphology at the University of Washington and his M.S. at Portland State University, Portland, Oregon on coastal processes.

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Doug Aberley has worked in British Columbia for nearly 25 years as a community and regional planner. After graduating with an MA in planning from University of British Columbia, he spent the first 16 years of his career in the Skeena Valley, employed primarily as administrator/planner for the Village of Hazelton. In the early 1990s Doug moved to Edinburgh, Scotland where he completed a doctorate in bioregional planning. He edited several volumes in this period, including *Boundaries of Home: Mapping for Local Empowerment*, and *Futures By Design: The Practice of Ecological Planning*. He is now an adjunct professor at the UBC School of Community and Regional Planning and also works as a land and resources planner for indigenous communities including the Tsleil-Waututh First Nation, Semiahmoo First Nation, and the Sencot'en Alliance.

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Linda Adams is currently the Director of Trust Area Services for the Islands Trust, a federation of island governments responsible for land use planning and protection of the island communities in the Georgia Basin, British Columbia. Her work includes the development and implementation of policies to achieve the Trust's provincial mandate. Linda has been a resident of Salt Spring Island for 17 years.

She is a member of the Canadian Institute of Planning. She has a B.Sc. with distinction in geography and biology from the University of Calgary. Prior to her current position, she spent nine years as the Islands Trust's senior planner for Salt

Spring Island. She is now engaged in a number of initiatives related to the Islands Trust's "Sustaining the Islands" program.

She is interested in policy and planning initiatives that move toward complete and sustainable communities, particularly those that can be implemented at the local level.

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Skip Albertson received his B.S. from Rensselaer Polytechnic Institute in physics and M.S. degrees in both mechanical engineering from U.C. Berkeley (1984) and oceanography from the University of Washington (1991). He is a registered professional engineer in both California and Washington. Now with the Washington State Department of Ecology, his interests include the application of hydrodynamic models to greater Puget Sound as well as water quality assessment and ecosystem dynamics.

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Jackie Amsden works for the Environmental Youth Alliance, where she is coordinating a mapping project with youth and writing a guide to community mapping to be used by other youth researchers. As well, she is completing her fourth year of studies in the department of communication at Simon Fraser University.

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Roland C. Anderson, Ph.D., is the Puget Sound Curator at the Seattle Aquarium. He is particularly interested in the natural history and behavior of Puget Sound cephalopods. He has published numerous articles on marine invertebrates of the Pacific Northwest in scientific journals and the trade

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Caroline Astley graduated from the University of Toronto and went on to pursue a diploma as a Fish and Wildlife Technician at Sir Sandford Fleming College. She is also currently completing GIS certification at Ryerson Polytechnic University. She has extensive experience working with non-profit organizations, with more than 12 years of volunteer experience, as well as with urban wildlife issues, having spent 2 years volunteering at a wildlife rehabilitation centre in Montreal.

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Amanda Babson is a 4th-year physical oceanography graduate student at the University of Washington in Seattle. She earned her B.A. in physics from Carleton College in Northfield, MN in 1998 and her M.S. in oceanography from UW in 2002. Her research focus is modeling Puget Sound circulation which she plans to expand into biological applications next.

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Jennifer Bailey is a member of the Applied Research Division at Royal Roads University. Her academic

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David Baldwin is an NRC post-doctoral fellow at the National Marine Fisheries Service's Northwest Fisheries Science Center. His research is focused on the sublethal impacts of contaminants on the sensory physiology and behavior of fish (particularly threatened or endangered salmonids). He received his doctorate in Zoology from the University of Washington (Seattle, WA) studying the physiology and behavior of the visual system of the fruit fly (*Drosophila melanogaster*).

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Donna Ball attends Western Washington University as a graduate student under the direction of John Rybczyk, Ph.D., in the Marine and Estuarine Science program at Huxley College. Her current research focuses on sediment dynamics in recently eradicated *Spartina alterniflora* sites in Padilla Bay and Willapa Bay, Washington.

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Russel Barsh is trained in human ecology and law at Harvard and has combined field research and teaching with community advocacy from Cape Breton Island to Kodiak Island and Puget Sound. He taught at the University of Washington (1974-1984), worked at the United Nations on indigenous peoples issues, including the Earth Summit, and most recently developed experimental courses on traditional knowledge at Dartmouth College and New York University before returning to the Northwest.

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1979-: Official of EU Commission: community development, transnational ecological networks, land use planning.
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Area of research interest:

Action-research fostering shared learning between regions addressing preservation and restoration of transboundary ecosystems.

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Dr. Dick Beamish is the senior scientist and former director at the Pacific Biological Station in Nanaimo. He has published more than 150 scientific articles on topics ranging from climate impacts on fish, to new species of fish. He has been a commissioner of the International Pacific Halibut Commission for more than nine years. He was appointed as the Department of Fisheries and Oceans representative on the New Pacific Fisheries Resource Conservation Council.

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John Bower's work includes research on predation in tern colonies, studying acoustic communication and population ecology of bowhead whales, taking censuses of wintering bald eagle populations along the Nooksack River, categorizing marbled murrelet vocalizations, and studying acoustic interactions in songbirds. He teaches field biology, ecology, and evolution at Fairhaven College, a part of Western Washington University, where he is starting a study sponsored by Washington Sea Grant to replicate important components of the 1970's MESA seabird census.

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Jim Dumont has more than 25 years of experience in the field of water resources, including all phases of planning, design and construction. He has been a leading proponent of continuous simulation-based designs in western Canada for the past 15 years. During that time he has been responsible for a variety of projects from planning studies that establish design criteria, to detailed design of complex hydraulic systems and municipal infrastructure projects. He has been invited to speak at several conferences and meetings, including the BCWWA annual meeting and WCWWA specialty conferences. He has also presented examples of his work at WEF, CWRA and CSCE conferences in addition to less formal settings for the public at open-houses and project meetings.

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Bruce Duncan was highly trained as a marine benthic invertebrate proctologist at the UW and UNC. He is a past-president of the Pacific Northwest SETAC, and EPA's member on the PSAMP steering committee. At EPA he provides ecological risk assessment support to various regional EPA program offices (Superfund, Water, etc.). PCB exposure and toxicity are areas of increasing interest to EPA as new methods are developed to evaluate congener toxicity and modeling approaches are considered for GB/PS.

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Susan Sargeant has studied shading effects of ferry terminals on eelgrass habitat, monitored eelgrass transplant and reference sites, and conducted bioassays to evaluate open-water dredge disposal sites in Puget Sound. She is a research diver for the laboratory, performing habitat and population estimates and assessments, underwater photography and videography. She brings to the MSL experience on salmonid issues, including studies on fish screening facilities, hydroacoustic fish passage through Snake and Columbia River hydroelectric projects, and the effects of gas supersaturated water on salmonids.

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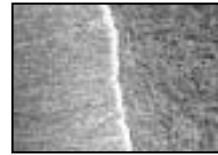
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